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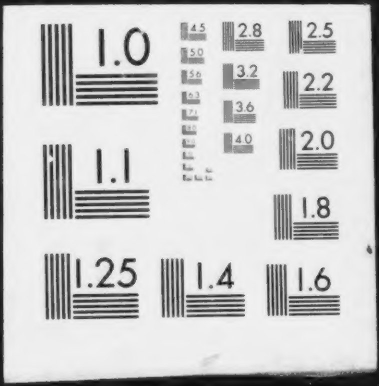
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Oxidant Air Pollutant Effects on a Western Coniferous Forest Ecosystem

California Univ, Riverside Statewide Air Pollution Research Ctr

Prepared for

Corvallis Environmental Research Lab, Oreg

Apr 78

PB 281 858

OXIDANT AIR POLLUTANT EFFECTS ON A WESTERN CONIFEROUS FOREST ECOSYSTEM

Annual Progress Report 1973-74

Task D

UNIVERSITY OF CALIFORNIA

STATEWIDE AIR POLLUTION RESEARCH CENTER

RIVERSIDE, CALIFORNIA

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16. ABSTRACT

This is an annual report for the year June 1973 through June 1974. Section I gives the location and brief description of the field layout for the ecosystem study on oxidant air pollution effects on a Western coniferous forest. Section II contains diagrams and descriptions of interactions between the disciplines involved in the selected areas of study. Section III contains reports prepared by researchers directing the research in 10 areas of interest.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
plant ecology, ecological succession, plant growth, forest land, plant reproduction, forest trees, pine trees	photochemical oxidants conifer ecosystems interdisciplinary investigations ecological responses	2/F 6/F 6/C

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Introduction

The annual report for Contract II 68-03-0273 for the year June 15, 1973 through June 14, 1974 contains three major sections. Section I gives the location and a brief description of the field layout for the ecosystem study. Section II contains diagrams and descriptions of interactions between the disciplines involved in the selected areas of study. Section III contains reports prepared by researchers directing the research in 10 areas of interest. These reports briefly describe activities during the past year.

Section I is prefaced by a brief summary of activities in the program and includes a diagram of the data capture, banking and analysis program which was designed by Dr. Barberii to accept information from all disciplines involved.

Close coordination with the San Bernardino National Forest Administration was handled by Mr. Jerry Light prior to his transfer. No report on this section was included because the wildlife biologist position he vacated has not been filled.

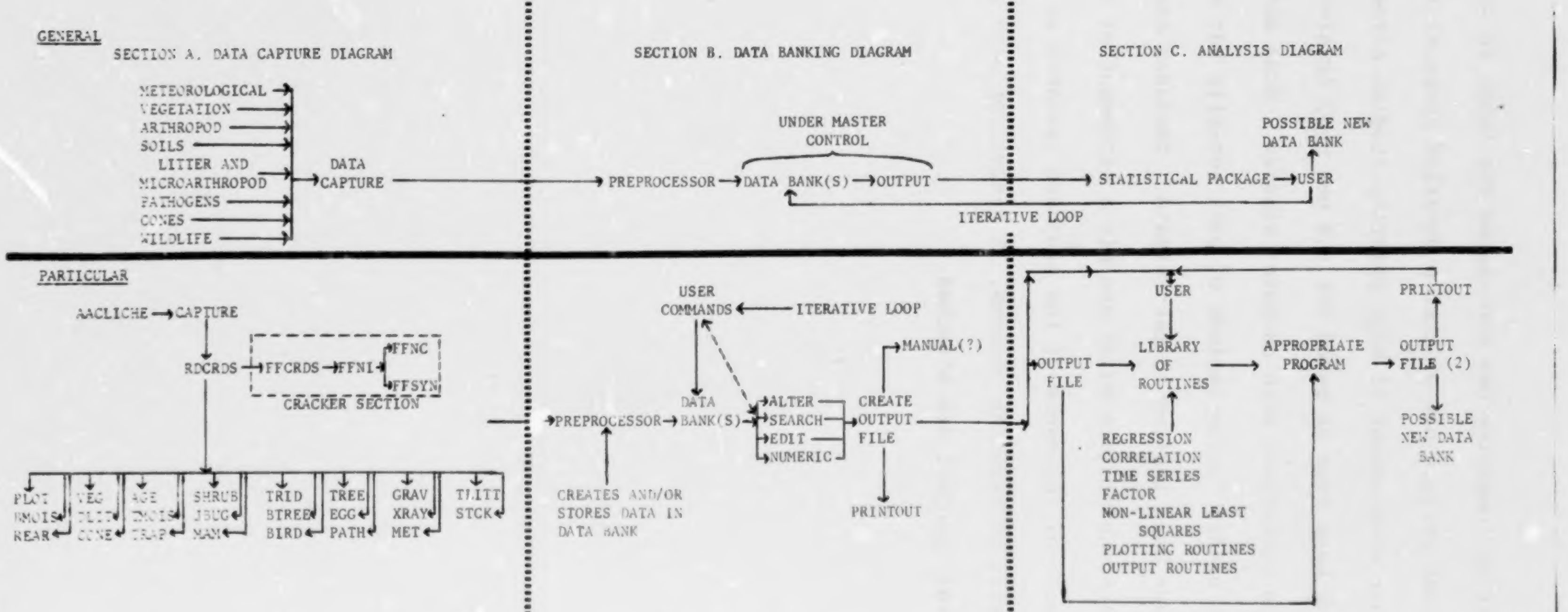
An effort is still being made to employ a systems analyst to assume the responsibility for developing ecosystem models appropriate for this study. Since modeling of the system was a major part of the program, it is essential that the services of a well qualified and, if possible, experienced analyst be obtained.

PROPOSAL FOR THE CONTINUATION OF FORMER CONTRACT # 68-03-0273 BETWEEN THE UNIVERSITY OF CALIFORNIA AND THE ENVIRONMENTAL PROTECTION AGENCY FOR THE STUDY OF THE IMPACT OF AMBIENT OXIDANT POLLUTANTS ON THE MIXED CONIFER FOREST ECOSYSTEM DURING FY 1975.

SUMMARY

During the first field season (FY 1974) important progress has been made towards the design and establishment of a system of field plots in which all sub-projects have gathered data in a coordinated manner. The air pollution injury levels in the 18 field plots indicate the nature of the oxidant gradient across the San Bernardino Mountain Area using ponderosa and Jeffrey pines as indicators. Locations have been selected and developed for air monitoring stations and additional plots for the study of bark beetle population dynamics. A second important area of progress was the design of standardized data gathering procedures and field data forms for each sub-project. These forms permit immediate entry of field data into the computer for storage in an integrated data bank. This data management system is nearly operational for all sub-projects. Data analysis procedures are yet to be worked out pending the hiring of a systems modeler who will be able to cooperate with those designing the data management procedures. A third category of progress is the design of provisional sub-models or interaction diagrams which define the important problems to be studied at one or more levels of biological organization, namely,the organism, the forest stand or community and the final level involving long term successional changes in forest vegetation which will determine the fate of the forest ecosystem. Further, each important interaction which must be studied has been assigned to a particular team of researchers who are cooperating in gathering the appropriate field data and in analysis of such data. A schedule of operations has been developed.

The project steering committee has considered the tasks to be done and the available budget and each sub-project has written a detailed proposal for FY 1975 work which represents further advancement of high priority studies already in progress. Any new studies which have been proposed for the new year involve data collection which may be done concurrent with on-going studies. Some additional temporary personnel may be needed during periods of peak activity but no new principal investigators have been invited to participate. Included are detailed research proposals for each sub-project which contain a statement of objectives, progress reports, statements of relevance of the proposed research to the goal of the project and details of research methods. A budget for each proposed sub-project and for the overall project are attached.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SECTION I

Field Layout for the Ecosystem Study

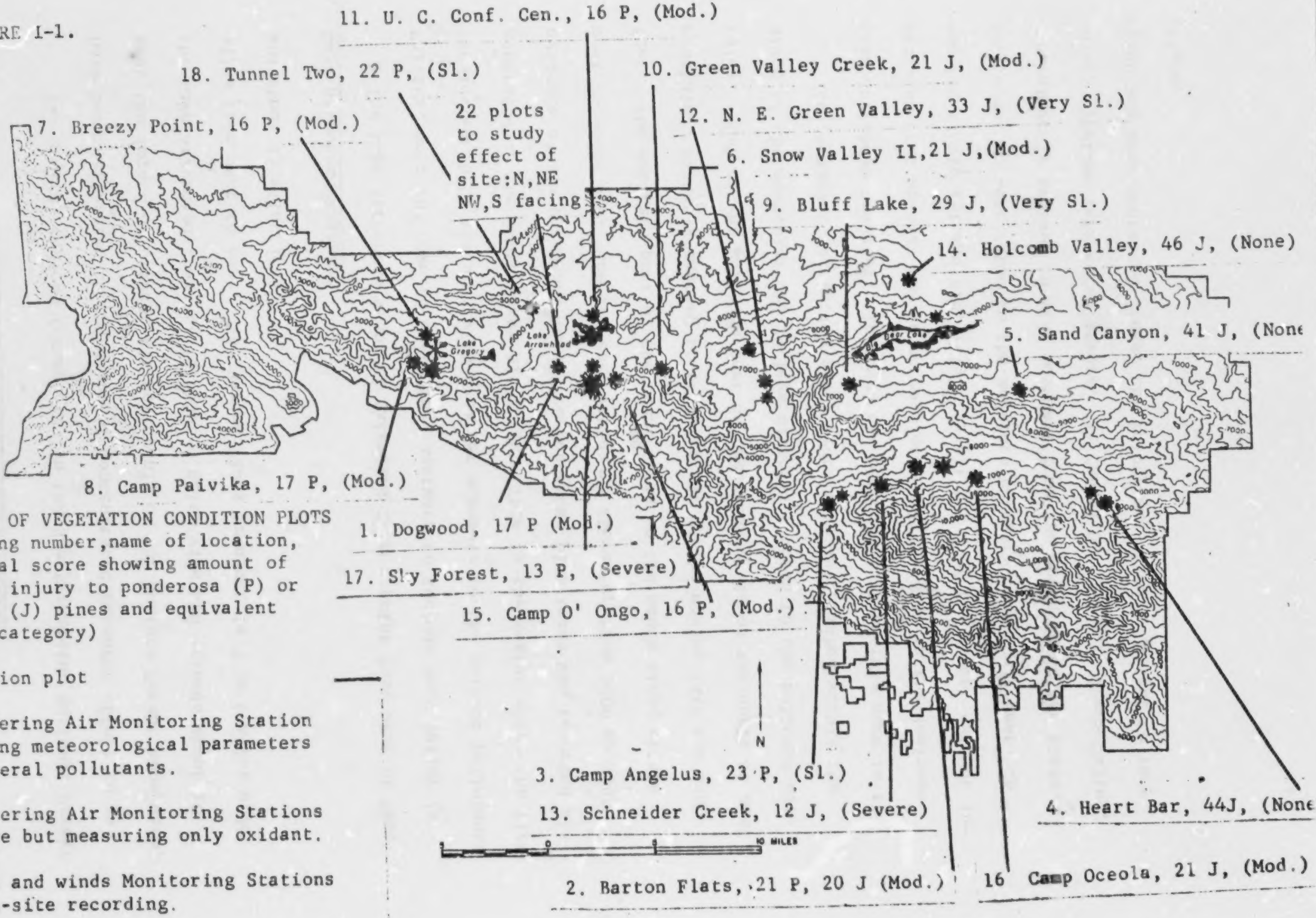
Two general regions (transects) in the San Bernardino National Forest have been designated as the areas of concentrated research effort to assess the impact of oxidant air pollutants on the Western Forest ecosystem. The Lake Arrowhead transect is about 4 miles wide and extends about 16 miles from west to east. The Barton Flats transect is 3 to 4 miles wide and about 15 miles long.

Lake Arrowhead Transect

The Lake Arrowhead transect extending from a point just west of Camp Paivika, near the town of Crestline, eastward to include Snow Valley is considered to be the area with greatest exposure to the oxidant pollutants generated in the South Coast Air Basin. This is the region where the first evidence of air pollutant injury on Ponderosa pine trees was reported almost 20 years ago. The transect varies in elevation from 3200 to 8095 feet. The southern part of the transect is on the south slope of the mountains, directly exposed to polluted air masses moving into the mountains. Much of the northern part of the transect is on the north or east slope of the mountains and is less directly exposed to the polluted air.

Ten permanent vegetation study plots were established within the Lake Arrowhead transect. In seven of these plots, Ponderosa pine is the dominant tree species and in three plots, Jeffrey pine is the dominant species (Table 1-1 and Fig. I-1). In all but 3 of the plots, oxidant injury symptoms were rated in the moderate category. At Sky Forest, an area directly exposed to wind movement from the South Coast Air Basin, injury symptoms were rated severe. At Tunnel Two and N.E. Green Valley, which are more protected areas, the injury was rated as slight to very slight.

FIGURE I-1.


11. U. C. Conf. Cen., 16 P, (Mod.)
18. Tunnel Two, 22 P, (Sl.)
10. Green Valley Creek, 21 J, (Mod.)
22 plots
to study
effect of
site:N,NE
NW,S facing
12. N. E. Green Valley, 33 J, (Very Sl.)
7. Breezy Point, 16 P, (Mod.)
6. Snow Valley II,21 J,(Mod.)
9. Bluff Lake, 29 J, (Very Sl.)
14. Holcomb Valley, 46 J, (None)
Lake Gregory
Lake Arrowhead
Big Bear Lake
5. Sand Canyon, 41 J, (None
8. Camp Paivika, 17 P, (Mod.)
1. Dogwood, 17 P (Mod.)
17. Sky Forest, 13 P, (Severe)
15. Camp O' Ongo, 16 P, (Mod.)
N
3. Camp Angelus, 23 P, (Sl.)
13. Schneider Creek, 12 J, (Severe)
4. Heart Bar, 44J, (None
0
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10 MILES
2. Barton Flats, 21 P, 20 J (Mod.)
16 Camp Oceola, 21 J, (Mod.)

LOCATIONS OF VEGETATION CONDITION PLOTS
(including number, name of location, numerical score showing amount of oxidant injury to ponderosa (P) or Jeffrey (J) pines and equivalent injury category)

- ✱ Vegetation plot
- ✱ Telemetering Air Monitoring Station measuring meteorological parameters and several pollutants.
- ✱ Telemetering Air Monitoring Stations as above but measuring only oxidant.
- ✱ Oxidant and winds Monitoring Stations with on-site recording.
- ✱ Bark Beetle Population Dynamics Plots

Table I-1. Lake Arrowhead Transect

Plot No.	Name	Dominant Pine Species	Rating of Oxidant Injury
1	Dogwood	Ponderosa	Moderate
7	Breezy Point	Ponderosa	Moderate
8	Camp Paivika	Ponderosa	Moderate
11	U.C. Conference Center	Ponderosa	Moderate
15	Camp O'ongo	Ponderosa	Moderate
17	Sky Forest	Ponderosa	Severe
18	Tunnel Two	Ponderosa	Slight
6	Snow Valley	Jeffrey	Moderate
10	Green Valley	Jeffrey	Moderate
12	N.E. Green Valley	Jeffrey	Very Slight

Barton Flats Transect

The Barton Flats transect, located south and east of the Lake Arrowhead transect, ranges in elevation from 3950 to 8950 feet. The Santa Ana River extends into the San Bernardino Mountains along the north side of this transect and provides access for the polluted air to invade a considerable distance into the National Forest. At the Schneider Creek plot, near the west end of the transect, oxidant injury was rated as severe (Table I-2). Further east along the Santa Ana River, drainage injury in the Barton Flats and Camp Oceola plots was rated moderate. Injury in the plots at the extreme west and extreme east end of the Barton Flats transect were rated slight or none (Table I-2 and Fig. I-1).

The dominant pine species at the lower elevation in the east end of the transect is Ponderosa. The eastern plots at greater elevation are predominantly Jeffrey pine. In both of the transects the forest is a mixture of Ponderosa, Jeffrey, and Sugar pine, White fir, Incense cedar, and Black oak, but a criterion for selecting study plots was to select areas where either Ponderosa or Jeffrey pine predominated.

Plots Outside the Transects

Three vegetation study plots were established in the area east of the Lake Arrowhead transect and north of the Barton Flats transect. These three plots were predominantly Jeffrey pine and the injury symptoms were rated at slight or none.

Pollutant-Meteorological Monitoring

A system of ten telemetering meteorological monitoring stations will be installed in the San Bernardino Forest by the U.S. Forest Service during the spring of 1974. A cooperative agreement has been worked out between those involved in the U.S. Forest Service study and the monitoring

Contents

Introduction

Summary - Continuation Proposal

Section I Field Layout for Study

Section II Interaction Diagrams

Section III Annual Progress Reports for Study Areas

Table I-2. Barton Flats Transect

Plot No.	Name	Dominant Pine Species	Rating of Oxidant Injury
3	Camp Angelus	Ponderosa	Slight
2	Barton Flats	Ponderosa & Jeffrey	Moderate
4	Hart Bar	Jeffrey	None
13	Schneider Creek	Jeffrey	Severe
16	Camp Oceola	Jeffrey	Moderate
	Vegetation Plots Outside the Two Transects		
5	Sand Canyon	Jeffrey	None
9	Bluff Lake	Jeffrey	Very Slight
14	Holcomb Valley	Jeffrey	None

subsection of Contract 68-03-0273 to share in the use of the telemetering stations. An additional telemetering station designed to record meteorological parameters and several pollutants will be installed at Sky Forest. Stations to monitor meteorological parameters and total oxidants will be installed at Camp Paivika and the Barton Flats. These three stations will share transmitting equipment installed by the U.S. Forest Service to transmit data to the Forest Fire Laboratory located adjacent to the U.C.R. campus. Non-telemetering stations to record wind speed and direction and total oxidant concentrations are installed at Snow Valley, Big Bear Ranger Station, Camp Angelus, and Hart Bar (See Fig. I-1).

SECTION II

INTERACTION DIAGRAMS

by McBride

Knowledge of the interactions between the components of an ecosystem is basic to the development of any ecosystem model. Three general models, each representing different levels of activity within the forests of the San Bernardino Mountains are being considered in this study. The first model will represent the effect of oxidant air pollution at the organism level. Figure 1 and Table II-1 illustrate the interactions which must be studied in order to develop this model. Sub-models, such as a tree model, will need to be developed as a part of the organism level modeling effort. Figure 1A and Table 1A represent the interactions pertinent to the development of a tree model.

The second model will represent the effects of air pollution at the community level. Interactions which need to be investigated for the development of this model appear in Figure 2 and Table 2. Here again, sub-models will need to be developed such as a stand model. Figure 2A and Table 2A represent the interactions which must be studied in order to develop a stand model.

The third model will represent the effects of smog on plant succession. Figure 3 and Table II-3 illustrate the interactions to be studied in developing this model. Sub-models may also be appropriate to the preparation of the plant succession model.

Identification of components of an ecosystem and an understanding of key interactions is essential information for development of an ecosystem model. The components of a western coniferous forest ecosystem with the primary component interactions considered to be basic to a model of air pollutant impact are illustrated in Figures 1,2,3 Composite. Models at three different levels are shown to give an overall view of the interactions currently considered basic to the ecosystem study.

An organism level model is presented in Figure II-1 and the types of interactions shown by numbered lines are listed in Table II-1. For this study, the most important direct impact of oxidant air pollutants on compounds of the organism level model are: (2) small animals; (4) soil microarthropods; (8) woodpeckers and other hole nesting birds; (10) the tree; (12) non-pathogenic fungi; and (14) pathogens. Other interactions more indirectly related to the air pollutant impact on the system are listed by number with the primary investigators and the year of initiation for each study.

An additional refinement of organism level interactions, Figure II-1A, recognizes some of the important physiological functions of the individual tree as influenced by oxidant air pollutants, other abiotic and some biotic factors. All numbered interactions followed by "a' indicate those influences exerted upon the tree while those followed by "b" or "c" indicate feedbacks influencing an external biological agent or environmental factor. Some of these interactions, Table II-1A, are currently under study or will be studied in succeeding years. Certain interactions involving basic tree physiology cannot be studied effectively unless other specialists are added to the research team. The proposed budget for FY1975 does not intend for this work to be initiated.

The diagramatic model of community level interactions, Figure II-2, illustrates the impact of various factors in the community, including air pollutants on plants. The primary receptor in this model is the plant community. The interactions indicated by numbered arrows are listed and briefly described in Table II-2, indicating the proposed year of initiation of the study.

The relative competitive capacity of tree, shrub, and herb layer vegetation in stands subjected to oxidant air pollutants is an important focal point at the community level. A representative stand diagram, Figure II-2A, shows the important interactions with the physical environment and consumer organisms which must be considered. Those responsible for studying each interaction and a schedule for the studies are summarized, Table II-2A. The direct influences of biotic or environmental factors on vegetation in stands is indicated by an "a" following the number of the interaction. An influence in the opposite direction is indicates by "b" or "c".

The influence of air pollutants and eight other major environmental factors on structure of a community in the ecosystem being studied is shown in Figure II-3. Each factor or combination of factors can have a very significant influence on change from community #1 to community #2. The primary investigators interested in each of the interactions and the proposed data of initiating work in each field are listed in Table II-3.

In summary, the foregoing diagrams and definitions of important interactions provide an integrated study plan which will continue to evolve as data is gathered. As work progresses during 1974-75 a better evaluation of each interaction will be developed so that priorities can be established for the development of submodels around those interactions which will be the most powerful predictors of plant community change in the mixed conifer forest. These submodels must in turn be interfaced to provide a comprehensive description of the fate of this western coniferous forest ecosystem damaged by oxidant air pollutants.

In the following section (III) a detailed research proposal is presented by each subproject. Each proposal keys its objectives back to Figures II-1, 2, and 3 in order to describe its relevance to the overall project goals. Each includes an individual budget.

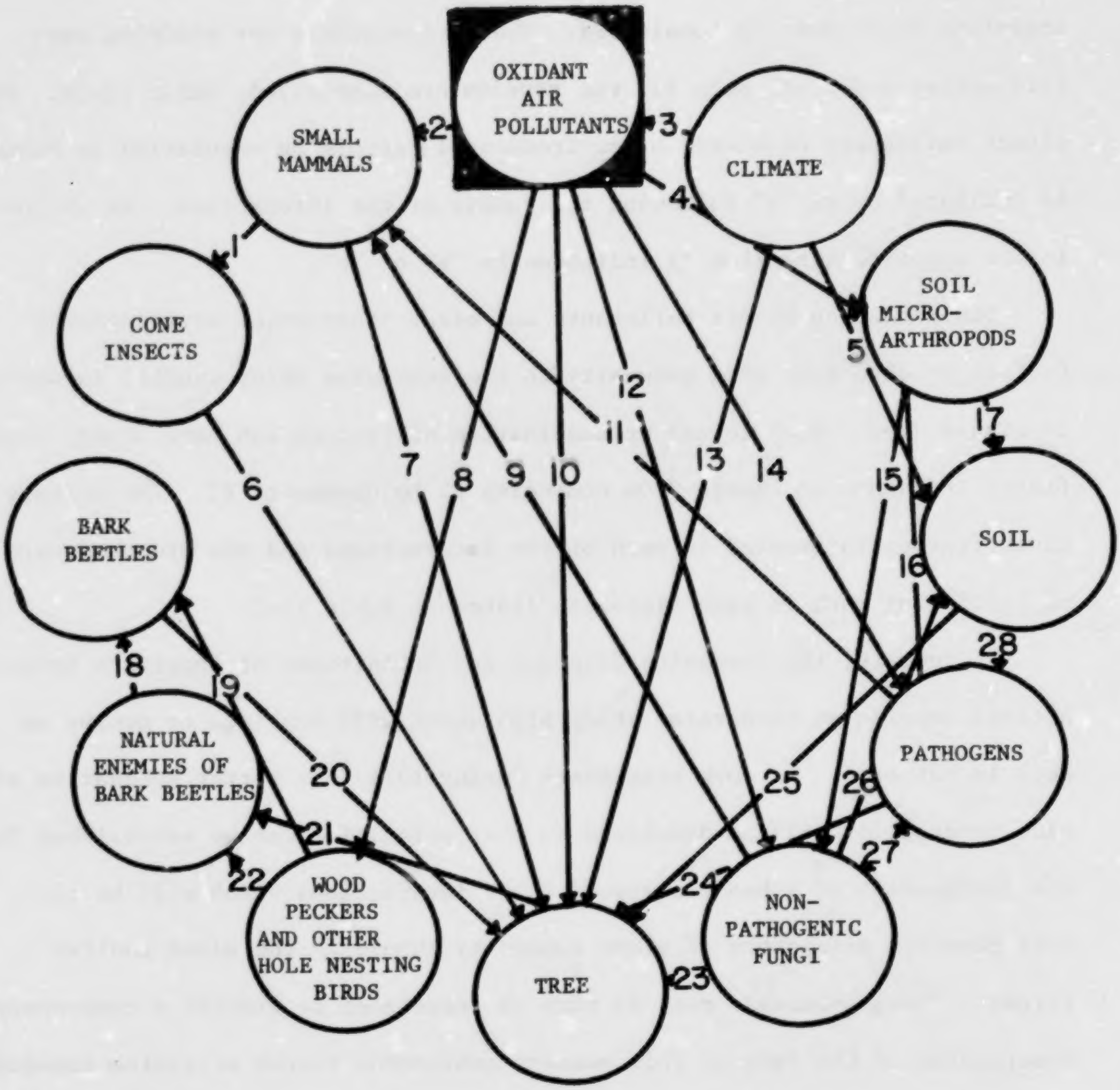
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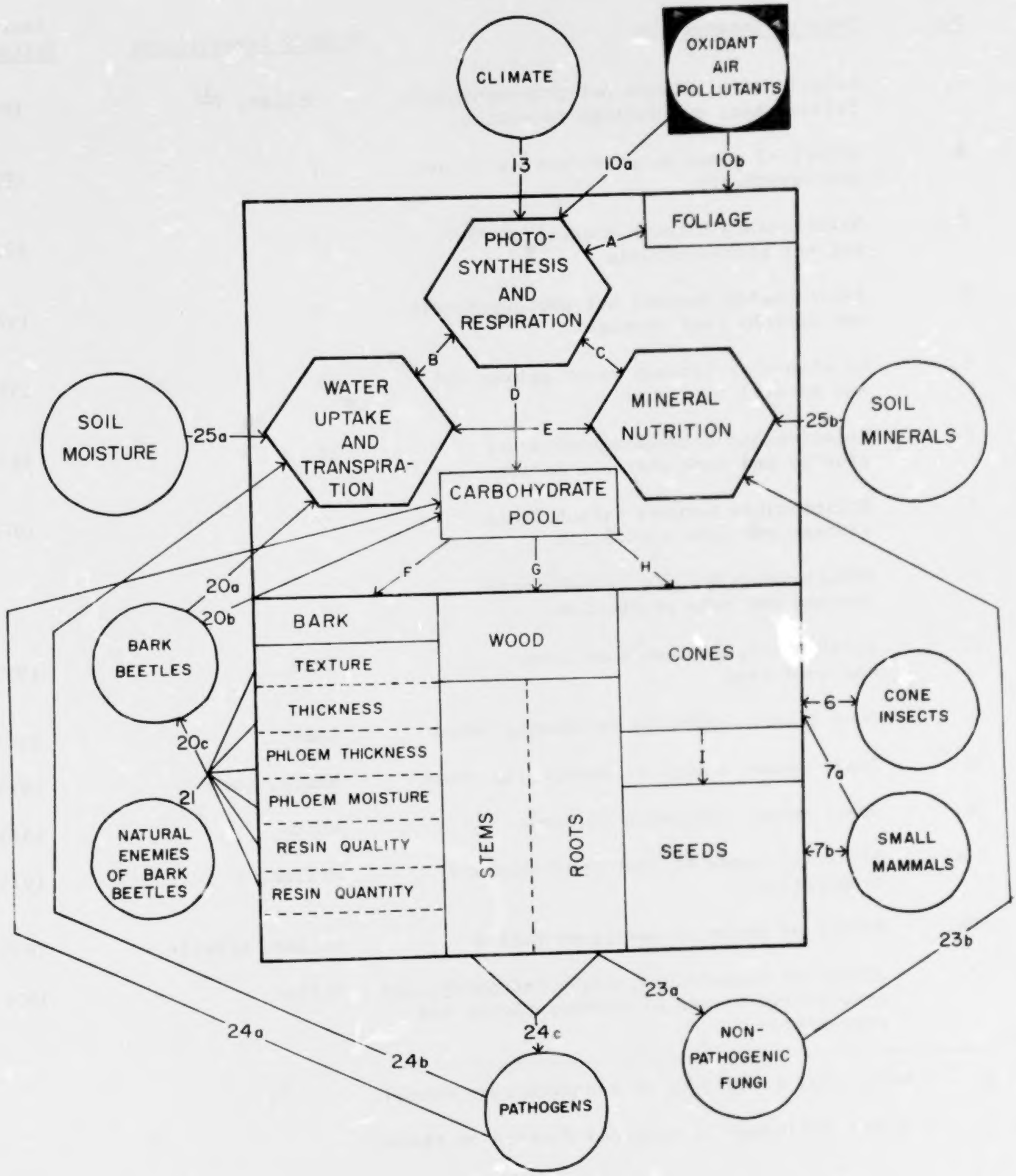
Fig. 1. ORGANISM LEVEL INTERACTION/SUBMODELS

Table II-1 List of organism level interactions shown in the model diagram in Figure II-1

No.	Type of Interaction	Primary Investigators	Year of Initiation
1.	Competition for food supply	White, Luck	1973
2.	Direct effect of ozone on small mammal physiology.	White, ?	1976
3.	Climatic control of oxidant concentration in the forest	Miller	1973
4.	Direct effect of ozone on soil microarthropods	Dahlsten (?)	1976
5.	Effect of precipitation and temperature on soil moisture and soil temperature	Arkley, Miller	1973
6.	Insect damage to developing cones	Luck	1973
7.	Small mammal damage to developing cones and the importance of cone crop as animal food supply	White, Luck	1973
8.	Direct effect of ozone on physiology of cavity nesting birds	Dahltsen, Balgooyen	1974
9.	The role of fruiting bodies of non-pathogenic fungi in the nutrition of small mammals	White, Parmeter, Cobb	1974
10.	Direct effect of ozone on tree physiology	Miller, McBride, Arkley	1974
11.	The role of fruiting bodies of pathogens in the nutrition of small mammals	White, Cobb, Parmeter	1974
12.	Direct effect of ozone on non-pathogenic fungi	Parmeter, Cobb, Weinhold	1974
13.	Effect of temperature and evaporative stress on tree growth	McBride, Miller	1974
14.	Direct effect of ozone on pathogenic fungi	Cobb, Parmeter, Weinhold	1974

Table II-1 (continued)

No.	Type of Interaction	Primary Investigators	Year of Initiation
15.	Interaction of non-pathogenic fungi and soil micro-arthropods	Wenz, Parmeter, Cobb,	1973
16.	Interaction of pathogenic fungi and soil micro-arthropods	Wenz, Cobb, Parmeter	1973
17.	Effect of soil microarthropods on litter reduction	Wenz, Arkley	1973
18.	Impact of predation and parasitism on bark beetles	Dahlsten	1973
19.	Predation of bark beetles by woodpeckers	Dahlsten, Balgooyen	1973
20.	Effect of bark beetles on tree mortality and vigor and the effect of phloem thickness and moisture on bark beetles	Dahlsten, McBride, Miller	1974
21.	Effect of phloem moisture and thickness on natural enemies of bark beetles	Dahlsten	1974
22.	Influence of woodpeckers on rate of parasitism	Dahlsten, Balgooyen	1973
23.	Effect of non-pathogenic fungi on tree growth	Cobb, Parmeter	1973
24.	Effect of pathogens on tree vigor and mortality	Parmeter, Cobb, Weinhold	1975
25.	Effect of soil moisture and soil temperature on tree growth	McBride, Arkley, Stone	1973
26.	Effect of soil moisture and temperature on the occurrence of non-pathogenic fungi	Parmeter, Cobb, Weinhold, Arkley	1974
27.	Interaction of pathogenic and non-pathogenic fungi	Cobb, Parmeter	1973
28.	Effect of soil moisture and temperature on the occurrence of pathogenic fungi	Cobb, Arkley	1974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25b
SOIL MINERALS
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SEEDS
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CONE INSECTS
7a
7b
SMALL MAMMALS
23b
23a
24a
24b
24c
PATHOGENS
NON-PATHOGENIC FUNGI

Fig 1A. TREE LEVEL INTERACTIONS

Table 1A

Tree Level Interactions

(See Fig. 1A)

No.	Type of Interaction	Primary Investigator	Year of Initiation
A.	Relationship between net photosynthesis foliage age, and foliage retention.	Miller, ?[1]	1975
B.	Effect of plant moisture stress on net photosynthesis	?	1976
C.	Relationship between mineral uptake and net photosynthesis	?	1976
D.	Relationship between net photosynthesis and carbohydrate storage	?	1976
E.	Relationship between water uptake and and mineral nutrition	?	1976
F.	Relationship between carbohydrate storage and bark characteristics	?	1976
G.	Relationship between carbohydrate storage and cone production	?	1976
H.	Relationship between carbohydrate storage and cone production		
I.	Relationship between cone crop and seed crop	Luck	1973
6.	Cone insect damage to developing cones	Luck	1973
7a.[2]	Small mammal damage to developing cones	White, Luck	1973
7b.	Small mammal predation of seeds	White	1973
10a.	Effect of ozone on photosynthesis and respiration	Miller, ?	1975
10b.	Effect of ozone on needle retention	Miller, McBride	1973
13.	Effect of temperature, light intensity, and evaporative stress of photosynthesis and respiration	Miller	1974

---

[1] ? = Additional scientists or research team needed.

[2] a = Direct influence of external factors on trees.

Tree Level Interactions, cont.

20a.	Effect of bark beetle on water uptake and transpiration and the relationships of tree moisture stress to bark beetle attack	Dahlsten, ?	1976
20b.	Effect of bark beetles on tree carbohydrate level and the relationships of carbohydrate level to bark beetle population in the tree	Dahlsten, ?	1976
20c.	Relationships between bark characteristics and bark beetle attack and population	Dahlsten, ?	1976
21.	Relationship between bark characteristics and natural enemies of bark beetles	Dahlsten	1975
23a.	Relationship between root characteristics and mycorrhizal forming non-pathogenic fungi	?	1975
23b.	Effect of non-pathogenic fungi on mineral uptake	?	1976
24a.	Effect of pathogens on tree carbohydrate level and the relationship of carbohydrate level to pathogen attack	Cobb, Parmeter, Weinhold	1975
24b.	Effect of pathogens on water uptake and transpiration	Cobb, Parmeter, Miller, Weinhold	1975
24c.[3]	Relationship between stem and root characteristics and pathogen attack	Cobb, Parmeter, Weinhold	1975
25a.	Effect of soil moisture level and temperature on water uptake and transpiration	Arkley, Miller	1976
25b.	Effect of soil mineral concentration and temperature on mineral nutrition of tree	Arkley, ?	1976

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[3] b or c = Influence of tree condition on external factors.

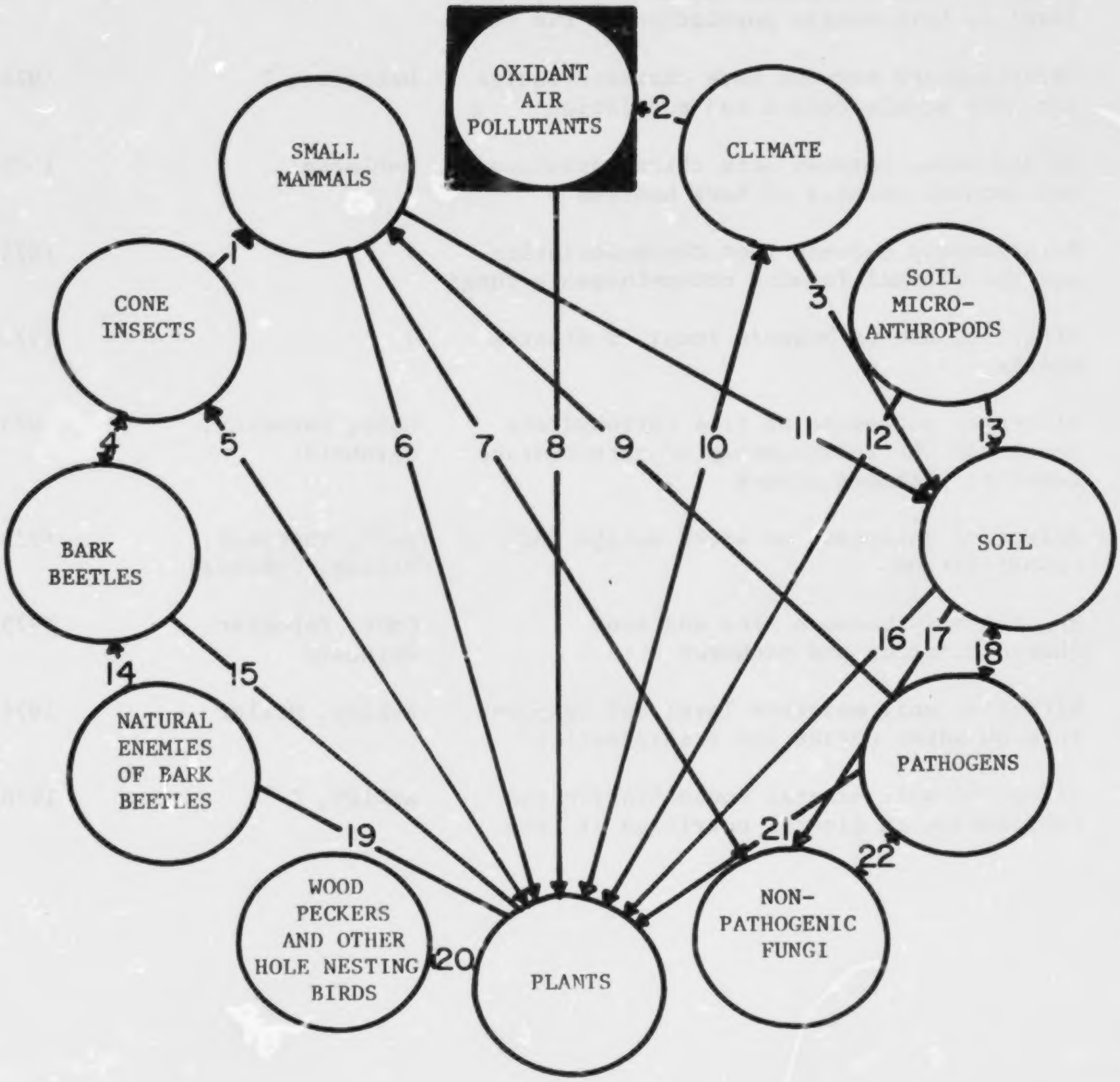
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Fig.2. COMMUNITY LEVEL INTERACTIONS/SUBMODELS

Table II-2 List and descripcion of community level interactions shown diagramatically in Figure II-2

No.	Type of Interaction	Primary Investigator	Year of Initiation
1.	Competition between woodpeckers and small mammals??	White, ?	1975
2.	Climate control of oxidant concentration in different forest communities	Miller	1973
3.	Effect of precipitation and temperature on soil moisture and soil temperature in different forest communities	Arkley, Miller	1973
4.	Predation of bark beetles by woodpeckers in different forest communities	Dahlsten	1973
5.	Effect of cone crop abundance on cone insect populations in different forest communities	Luck	1973
6.	Effect of cone crop abundance on small mammal populations in different forest communities	Luck, White	1973
7.	Fruiting bodies of non-pathogenic fungi as food for small mammals in different forest communities	White, Parmeter, Cobb	1974
8.	Smog caused mortality and morbity in different forest communities	Miller	1973
9.	Fruiting bodies of pathogens as food for small mammals in different forest communities	White, Cobb, Parmeter	1974
10.	Effect of temperature and evaporative stress on species composition in different forest communities	Miller, McBride	1974
11.	Relationship between soil characteristics and the population density of burrowing small mammals in different forest communities	White, Arkley	1974
12.	Influence of forest community type on soil microarthropod population	Wenz, McBride	1973

Table II-2 (Continued)

No.	Type of Interaction	Primary Investigator	Year of Initiation
13.	Relationship between soil characteristics and microarthropod population	Wenz, Arkley	1973
14.	Bark beetle mortality caused by natural enemies in different forest communities	Dahlsten, McBride	1973
15.	Effect of bark beetles on tree mortality and vigor in different forest communities	Dahlsten, McBride	1973
16.	Relationship between soil characteristics and forest community composition and growth	Arkley, McBride	1973
17.	Relationship between soil characteristics and species distribution and behavior of non-pathogenic fungi	Arkley, Parmeter, Cobb Weinhold	1974
18.	Relationship between soil characteristics and species distribution and behavior of pathogens	Arkley, Cobb, Parmeter, Weinhold	1974
19.	Influence of forest community type on the populations of the natural enemies of bark beetles	Dahlsten, McBride	1973
20.	Woodpecker distribution and density in different forest communities	Dahlsten, Balgooyen	1973
21.	Effect of pathogens on tree vigor and mortality in different forest communities	Cobb, Parmeter, Miller, McBride	1974
22.	Relationship between non-pathogenic fungi and forest community composition and growth	Parmeter, Cobb, Weinhold McBride	1975

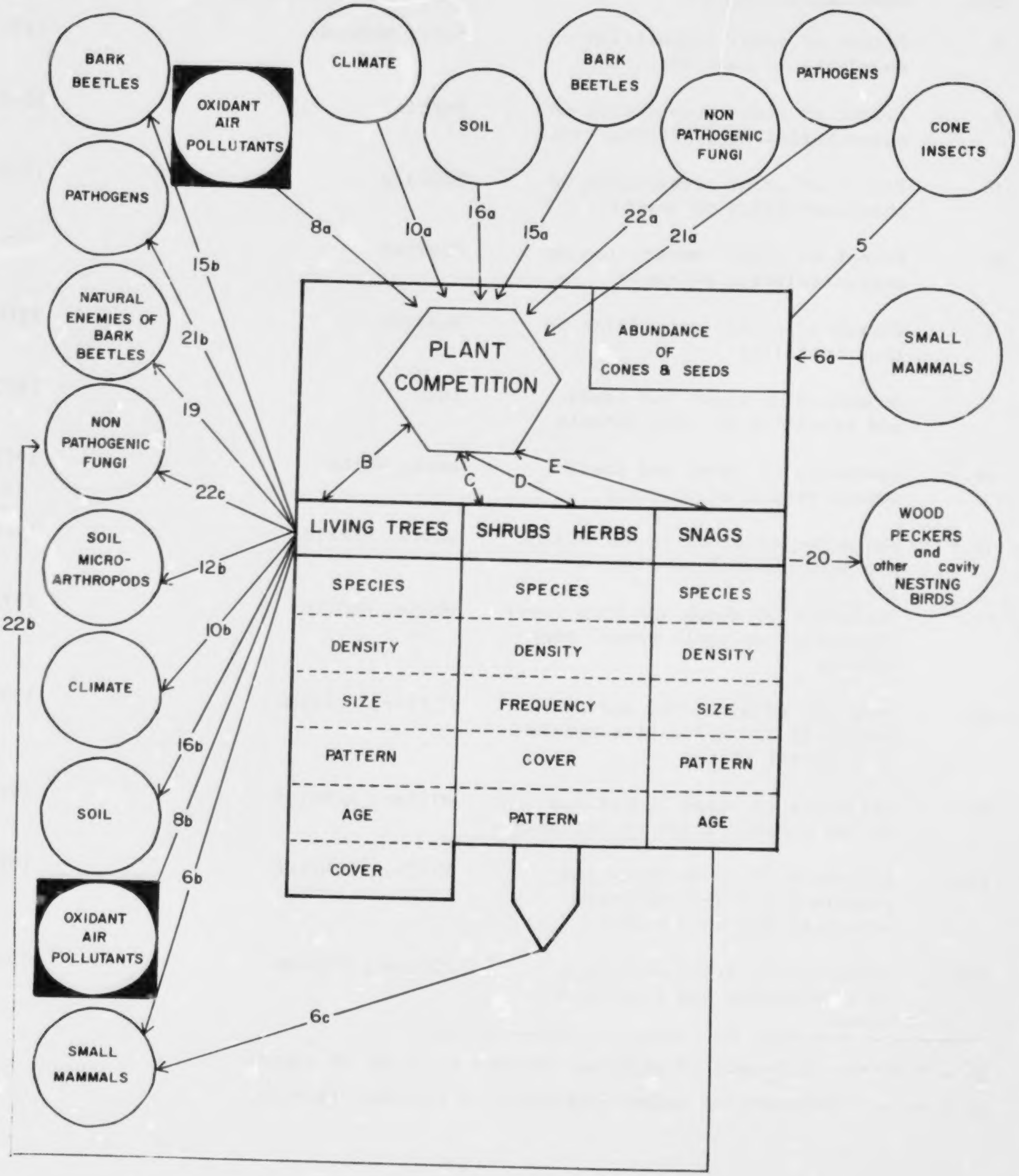

BARK BEETLES
OXIDANT AIR POLLUTANTS
CLIMATE
SOIL
BARK BEETLES
NON PATHOGENIC FUNGI
PATHOGENS
CONE INSECTS
PATHOGENS
NATURAL ENEMIES OF BARK BEETLES
NON PATHOGENIC FUNGI
SOIL MICRO-ARTHROPODS
CLIMATE
SOIL
OXIDANT AIR POLLUTANTS
SMALL MAMMALS
8a
10a
16a
15a
22a
21a
5
15b
21b
19
22c
12b
10b
16b
8b
6b
6c
22b
PLANT COMPETITION
ABUNDANCE OF CONES & SEEDS
6a
SMALL MAMMALS
B
C
D
E
LIVING TREES
SHRUBS HERBS
SNAGS
SPECIES
DENSITY
SIZE
PATTERN
AGE
COVER
SPECIES
DENSITY
FREQUENCY
COVER
PATTERN
SPECIES
DENSITY
SIZE
PATTERN
AGE
20
WOOD PECKERS and other cavity NESTING BIRDS

Fig 2A. STAND LEVEL INTERACTIONS

Table 2A

Stand Level Interactions

(See Fig 2A)

No.	Type of Interaction	Name of Investigator	Year of Initiation
A.	Effect of plant competition on abundance of cone and seeds	Luck, McBride	1976
B.	Effect of plant competition on characteristics of living trees	McBride	1976
C.	Effect of plant competition on characteristics of shrubs	McBride	1976
D.	Effect of plant competition on characteristics of herbs	McBride	1976
E.	Effect of plant competition on tree mortality	McBride	1976
5.	Abundance of cones and seeds and predation by cone insects	Luck	1973
6a.[1]	Abundance of cones and small mammal predition of cones	Luck, White	1973
6b.[2]	Characteristics of forest stands and small mammal populations	White, McBride	1973
6c.[2]	Influence of shrub and herb layer vegetation on small mammal populations	White, McBride	1973
8a.	Smog caused mortality and morbidity in different tree species with forest stands	Miller, McBride	1973
8b.	Influence of stand conditions on the concentration of oxidants	Miller, McBride	1973
10a.	Influence of temperature and evaporative stress on stand structure and composition	Miller, McBride	1973
10b.	Influence of stand condition on temperature and evaporative stress	Miller, McBride	1974

---

[1] a = Direct influence of external factors on trees in stands.

[2] b or c = Influence of stand conditions on external factors.

(Stand Level Interaction, cont.)

12b.	Influence of stand condition on soil microarthropod populations	Wentz, McBride	1973
15a.	Influence of bark beetle caused tree mortality on stand condition	Dahlsten, McBride	1973
15b.	Influence of stand condition on bark beetle population	Dahlsten, McBride	1973
16a.	Influence of soil moisture and and temperature on stand characteristics	Arkley, McBride	1973
16b.	Influence of stand condition on soil characteristics	Arkley, McBride	1973
19.	Influence of stand conditions on the population dynamics of the natural enemies of bark beetles	Dahlsten, McBride	1973
20.	Relationship between smog occurrence and woodpecker population level	Dahlsten, Balgooyen	1973
21a.	Influence of pathogen caused mortality on stand condition	Cobb, Parmeter, Miller, McBride	1974
21b.	Influence of stand condition on pathogen population	Cobb, Parmeter, Miller, McBride	1974
22a.	Influence of mycorrhiza fungi		
22b.	Influence of snags (and downed trees) on non-pathogenic fungi	Wilcox, Parmeter, Cobb, Weinhold	1975
22c.	Influence of stand condition on non-pathogenic fungi	Wilcox, Parmeter, Cobb, Weinhold	1975

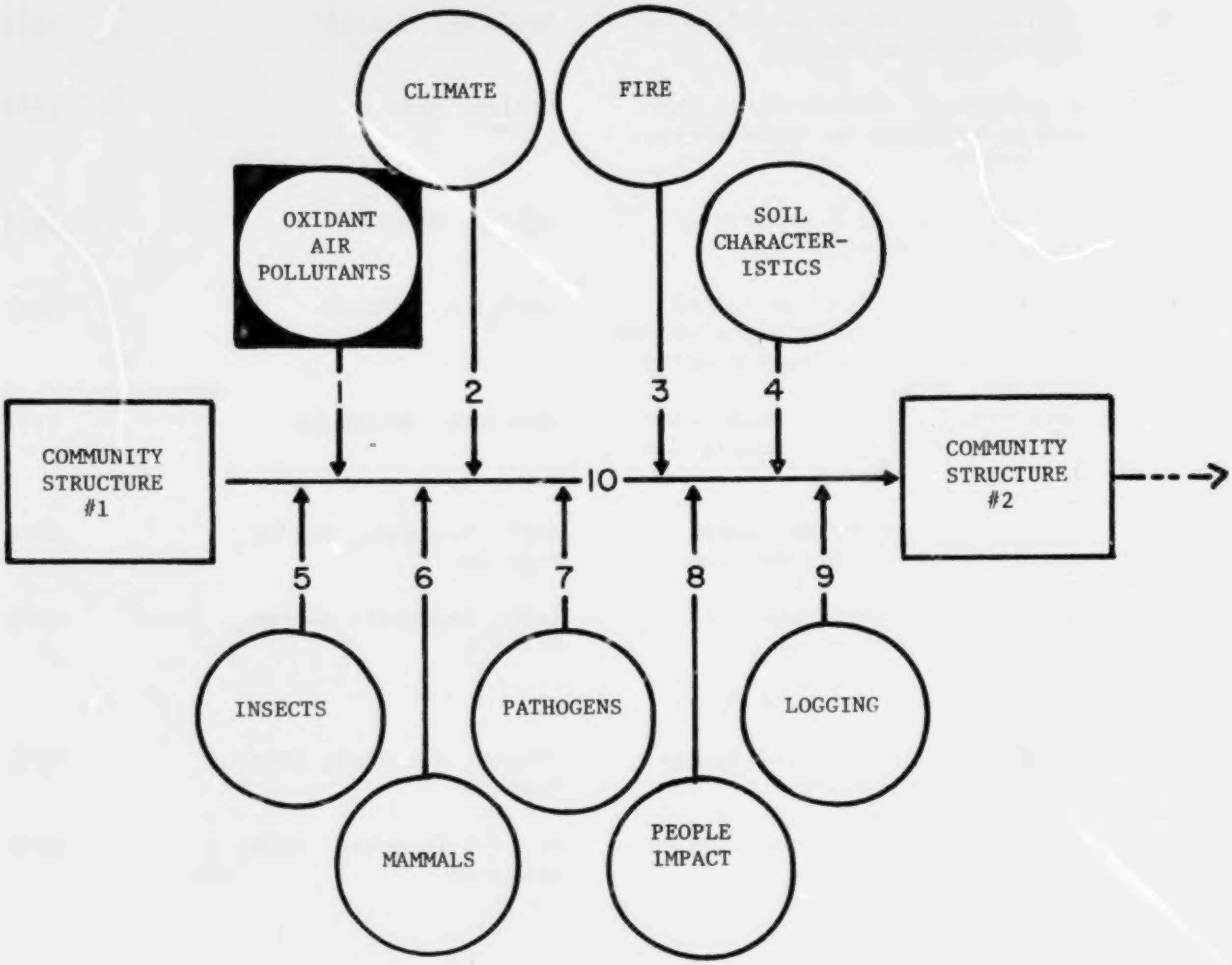

CLIMATE
FIRE
OXIDANT AIR POLLUTANTS
SOIL CHARACTERISTICS
1
2
3
4
COMMUNITY STRUCTURE #1
10
COMMUNITY STRUCTURE #2
5
6
7
8
9
INSECTS
PATHOGENS
LOGGING
MAMMALS
PEOPLE IMPACT

Fig. 3 PLANT SUCCESSION INTERACTIONS/PREDICTIVE MODEL

Table 3

Plant Succession Interactions

(See Figure 3)

No.	Type of Interaction	Primary Investigator	Year of Initiation
1.	Oxidant modification of community structure	Miller, McBride	1973
2.	Climate modification of community structure	Miller, McBride	1973
3.	Figure modification of community structure	McBride	1974
4.	Soil characteristics and their influence on community structure	Arkley, McBride	1973
5.	Insect modification of community structure	Dahlsten, Luck, McBride	1973
6.	Mammal modification of community structure	White, McBride	1973
7.	Pathogen modification of community structure	Cobb, Parmeter, Miller Weinhold, McBride	1974
8.	People impact on community structure	McBride, Miller, Dahlsten	1976
9.	Logging modification of community structure	McBride	1973

FIGS. 1, 2, & 3. (composite)

INTERACTIONS UNDER INVESTIGATION IN THE STUDY OF OXIDANT AIR POLLUTANT EFFECTS ON A WESTERN CONIFEROUS FOREST ECOSYSTEM

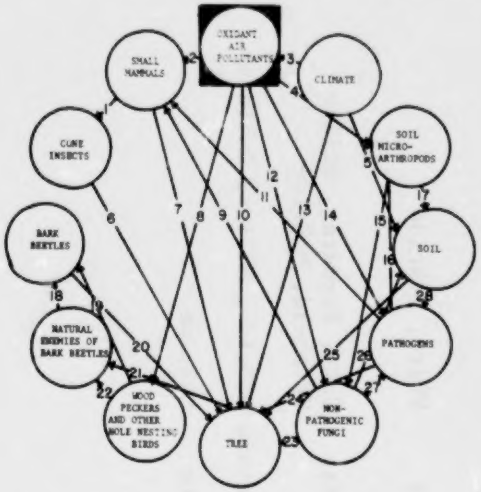

OXIDANT AIR POLLUTANTS
SMALL MAMMALS
CLIMATE
CONE INSECTS
SOIL MICRO-ARTHROPODS
BARK BEETLES
SOIL
NATURAL ENEMIES OF BARK BEETLES
PATHOGENS
WOOD PECKERS AND OTHER HOLE NESTING BIRDS
NON-PATHOGENIC FUNGI
TREE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28

Fig. 1. ORGANISM LEVEL INTERACTION/SUBMODELS

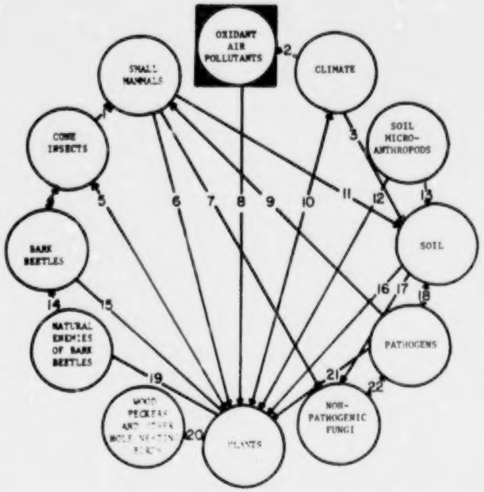

OXIDANT AIR POLLUTANTS
SMALL MAMMALS
CLIMATE
CONE INSECTS
SOIL MICRO-ARTHROPODS
BARK BEETLES
SOIL
NATURAL ENEMIES OF BARK BEETLES
PATHOGENS
WOOD PECKERS AND OTHER HOLE NESTING BIRDS
NON-PATHOGENIC FUNGI
PLANTS
1
2
3
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

Fig. 2. COMMUNITY LEVEL INTERACTIONS/SUBMODELS

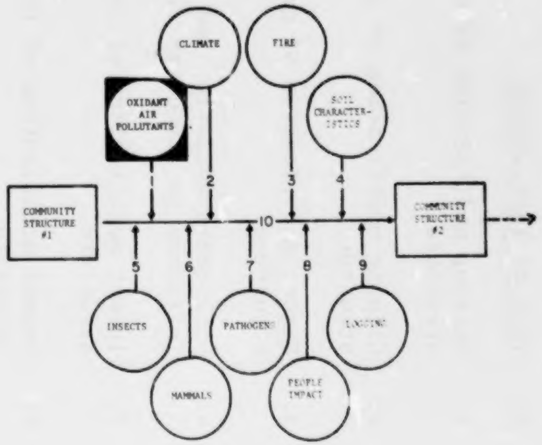

OXIDANT AIR POLLUTANTS
CLIMATE
FIRE
SOIL CHARACTERISTICS
COMMUNITY STRUCTURE #1
COMMUNITY STRUCTURE #2
INSECTS
MAMMALS
PATHOGENS
PEOPLE IMPACT
LOGGING
1
2
3
4
5
6
7
8
9
10

Fig 3 PLANT SUCCESSION INTERACTIONS/PREDICTIVE MODEL

SECTION III

Research Projects Incorporated into the Study of the Impact of Oxidant Air Pollutants on a Western Forest Ecosystem

III A. Miller, P.R. et al. Environmental monitoring and measurement of oxidant damage to vegetation in the San Bernardino Mountains.

III B. McBride, J.R. Effect of oxidant air pollutants on the successional patterns in forests dominated by Ponderosa and Jeffrey pine.

III C. Dahlsten, D.L. et al. The role of bark beetles, *Dendroctonus* ssp., in the succession of the mixed conifer ecosystem exposed to photochemical air pollutants.

III D. Parmeter, J.R. et al. Effects of photochemical air pollutants on microbial activity associated with litter decomposition and nutrient cycling.

III E. Cobb, F. et al. Effects of photochemical air pollutants on the epidemiology of root pathogens in the mixed-conifer forest.

III F. Wilcox, W.W. Effect of air pollutants on litter accumulation and soil properties.

III G. Wenz, J.M. et al. Effects of oxidant air pollutants on forest floor microarthropods.

III H. Arkley, R.J. and P.L. Gersper Effects of air pollutants on litter accumulation, soil properties, and soil-plant-climate interactions.

III I. Luck, R.F. Reproductive biology of certain coniferous components of the San Bernardino mountain ecosystem. I. Coniferous cone and seed production.

III J. Light, Jerry Coordination between the San Bernardino National Forest Administration and activities by the ecosystems contract.

III K. White, Marshall Effect of oxidant air pollutants on the vertebrate animal community.

III-A

ENVIRONMENTAL MONITORING AND MEASUREMENT OF OXIDANT DAMAGE TO VEGETATION IN THE SAN BERNARDINO MOUNTAINS

Continuous Monitoring of Air Pollutants and Associated Meteorological Factors Near Forest Ecosystem Study Sites

Principal Investigator: Dr. Paul R. Miller

Cooperating Scientists:

Dr. Rod Arkley, U. C. Berkeley - Soil moisture measurements.

Dr. Clif Taylor, U. C. Riverside - Air Pollution monitoring technology.

Mr. Morris McCutchan, U. S. Forest Service Fire Laboratory Riverside - In charge of base station facility for shared telemetry and data storage systems.

Dr. Joe McBride, U. C. Berkeley - Vegetation condition, in relation to site-microclimate-pollutant interactions.

Introduction

The present activities of this sub-project are divided into three general studies:

1. Determine climatic controls of oxidant concentrations and the extent and severity of oxidant injury to forest vegetation.
2. Measure the direct effects of oxidant injury to forest vegetation.
3. Measure the secondary effects of oxidant injury to forest vegetation.

The relationship of these general studies to the investigation of the specific interactions at the organism, tree, community stand and ecosystem levels are outlined in Table III-1. A data base is being generated which will allow for an analysis of these named interactions. The most progress was made in two of the three study areas during 1973-74 and will be described as:

1. Monitoring air pollutant concentrations and meteorological factors.
2. Measuring the extent and severity of oxidant injury to ponderosa and Jeffrey pines in the mixed conifer type.
3. Comparison of oxidant injury to all conifer species and kellogg black oak in the major vegetation study plots.

Results of other studies will be summarized in less detail.

I. Monitoring air pollutant concentrations and meteorological factors.

Seasonal Trends and Transport Phenomena - From April through December 1973, total oxidant air pollution was measured at one or more of the three station locations shown in Figure III-1a. The monthly summaries of these data are shown in Table III-2. July and August were the most severe months in 1973; Rim Forest or Sky Forest received the highest concentrations and longest daily durations of adverse oxidant levels (>0.08 ppm). The noticeable depression of total oxidant levels at Barton Flats in August may be due to the local afternoon thundershower activity which is typical at this time and location.

The total oxidant at Rim Forest/Sky Forest from April 1973 through June 1974 showed a marked increase in the early summer of 1974 compared to 1973 (Fig. III-2). The monthly peak of 0.60 ppm in June 1974 is the highest momentary peak ever recorded at this location during six years of operation. The average of the maximum hourly averages for June 1974 also exceeds any previous record.

The variability in hourly changes of total oxidant concentrations at Sky Forest, Barton Flats and Big Bear Ranger Station are compared in Figures III-3, III-4 and III-5. These particular days were chosen because the synoptic weather pattern, namely, a high pressure system offshore and elevated temperatures could be expected to coincide with higher oxidant levels. This bias permits an evaluation of the worst possible condition at all points throughout the monitoring network. The inclusion of wind speed and direction data mainly at Sky Forest and Big Bear Ranger Station helps to identify the general flow patterns associated with these episodes of elevated oxidants.

Generally the peak of total oxidant concentration each day coincides with the peak wind speeds for the day dominantly from the south at Sky Forest and southwest at Big Bear Ranger Station. The peak occurred earlier at Sky Forest than at Big Bear Ranger Station which is about 16 miles farther to the east (Figures III-1a and III-5). However, the selection of sample days from August, September, October and November (Figures III-3, III-4, III-5) readily illustrates how difficult it is to generalize about the passage of the "smog front" across the mountains. Observe that the chronological sequence of oxidant peaks on October 18 and 19 (Figure III-4) are very different; the wind data does not clearly explain why. The generally higher concentrations at Barton Flats in September, October and November compared to Sky Forest may suggest that the cool polluted air flows more readily up the Santa Ana River canyon than it can be lofted upslope during these months when slope heating is not as great as in July and August (Figures III-4 and III-5). The winds recorded during September, October and November do not substantiate this hypothesis because they suggest upslope flow. Perhaps the increased "maturity" of the photochemical smog air mass at Barton Flats which is farther east southeast (17 miles) than Sky Forest in a large canyon where there may be less dilution could contribute to the slightly higher total oxidant. A precise description of the flow of air pollution across the mountains is far beyond the capability of our project and its limited monitoring network. It is more important to correlate visible injury near monitoring stations with the observed oxidant doses and local weather conditions. To facilitate this objective a digest of the daily air pollutant and weather (winds, temperatures and relative humidity) data has been prepared for April through December 1973, and distributed to other sub-projects. Hourly values for all variables have been keypunched and will be available for more precise manipulation. In 1973-74, the only station with total oxidant, NO_2, PAN, total particulates (with Pb and Cd) winds, temperatures and relative humidity was Sky Forest.

Beginning in February 1974 and April 1974, total oxidant monitoring was resumed at Sky Forest and Barton Flats respectively. By June, an additional group of stations was in operation or being installed (Figure III-1b).

Three of these stations, Camp Paivika, Sky Forest and Barton Flats, were equipped to telemeter winds, temperatures, net radiation, relative humidity and ozone (by DASIBI ultraviolet spectrometer) to a Forest Service Master Station at Riverside. A sample of the hourly teletype printout is included (Exhibit III-1). The data is simultaneously recorded on magnetic tape. The newly established Air Pollution Control District Stations at Lake Gregory and Big Bear Lake (Parks and Recreation Department) will also provide oxidant data. The new configuration of stations will be better distributed in relation to the 18 vegetation plots.

Relative Concentrations of Several Pollutants at Sky Forest. The daily chronology of peak concentrations of total oxidant, PAN and NO_2 can be compared at Sky Forest (Figures III-3, III-4 and III-5). On August 13 and 14, (Figure III-3) PAN approached 8-11 ppb when total oxidant concentrations were peaking between 0.35 and 0.40 ppm. These PAN concentrations would cause damage to sensitive agricultural plants. The great majority of grasses and annual herbs would have already completed flowering by this date. Unpublished studies by Taylor and Miller have failed to show any conclusive injury to monterey or ponderosa pine at PAN doses far exceeding those observed on August 13 and 14. Herbs and other broadleaf species have been carefully observed during the early spring and summer by this project and members of Dr. McBride's project. The effort was somewhat muddled by a frost in late May which caused extensive injury to the youngest foliage of many species. The air pollutant-like symptoms which began to appear on herbs and grasses in late June could not be conclusively attributed to one or the other, neither ozone nor PAN. Scrutiny of the 1974 air monitoring data and fumigations of selected species with ozone and PAN will be required to clarify the role of PAN.

The PAN peaks have generally been observed to occur slightly after the total oxidant peaks in the majority of examples but simultaneous or even precedent PAN peaks have occurred.

The expected inverse relationship between NO_2 and total oxidant concentrations has been consistent at Sky Forest. The observed doses of NO_2 alone should not be expected to cause visible plant injury.

A Meloy sulfur analyser is presently being calibrated by the California Air Resources Board to be put into service at Sky Forest in July 1974.

The November 15-16, 1973 data in Figure III-5 provides a side-by-side comparison of the Mast instrument (total oxidant) and the DASIBI ultraviolet spectrometer which is specific for ozone. This field test does not suggest any major discrepancies in the instrument readouts. Because the DASIBIS will be used at the telemetering stations and Masts at all others, side-by-side comparisons will continue.

II. Measuring the extent and severity of oxidant injury to ponderosa and Jeffrey pine in the mixed conifer zone.

Injury data were collected in 1973 from the 18 major project study plots, associated sapling plots and U.S. Forest Service timber inventory plots scattered at random throughout the mixed conifer types of the San Bernardino National Forest. The Timber Inventory maps constructed from 1:12,000 color aerial photos taken in 1972 became available in February 1974. John Zorich transferred the external boundaries of existing conifer forest from these four inch = one mile maps to a one inch = one mile map of the National Forest. Grasslands, barrens and recent burns were delineated within the mixed conifer boundaries. The oxidant injury score values for each plot were located on this working map and isopleths delineating zones of injury corresponding to the established method described in the following Section 3. Injury data was available for all other tree species, when present, but ponderosa and Jeffrey pines were used here because they have similar ozone sensitivities and are more ubiquitous than other species. A third generation map with a smaller scale suitable for this report was prepared using the data points plus intuitive information relating topography to visible pollutant flow. The product of this effort, Figure III-6, is considered a preliminary effort which will be continuously improved as new data points are established. The next edition will be done at one inch = one mile so that non-forested or burned areas within the mixed conifer type can be included. In the present map all forested areas above 8000 teet were excluded because no data points were available and the Jeffrey pine dominated forest above that elevation is marginal and soon grades into lodgepole pine at its upper limits (8500 - 9000 ft). We wish to make it clear that we do not consider the higher elevation forests unimportant but simply second priority in a full work schedule.

It is hoped that new aerial photography planned by the Forest Service, Region 5, Pest Control will help improve the map. Computer graphic techniques have been investigated and may be useful when more data points are available to construct an improved map.

3. Comparison of oxidant injury to all conifer species and black oak in the major vegetation study plots.

The determination of oxidant injury to various tree species in the initial 6 plots in 1972 suggested that improved methods were needed to evaluate oxidant injury to white fir, incense cedar and black oak. The scoring procedure for ponderosa, Jeffrey and sugar pines was already satisfactory. This procedure was described in the Task C Report, 1973. The standard procedures for scoring injury to white fir, incense cedar and black oak were finalized and tested in 1973. All evaluations were done in September and early October.

Methods - The detailed procedures for white fir, incense cedar and black oak are as follows:

White Fir:

Upper Crown

1. Select a sunlit branch on the 5th branch whorl from the top on the main stem.

2. Arbitrarily divide the selected branch into an inner half (towards the bole) and an outer half (towards the branch tip).

3. Rate the needle retention on each branch segment as 0 = none present, 2 = thin complement, and 4 = full complement. The highest possible score is 8.

4. Rate the condition of the needles on each segment of the branch as: 0 = absent or completely brown, 2 = chlorotic mottle or yellow, and 4 = green. The highest possible score is 8.

5. In general view, determine if needles of the upper crown are normal length = 1 or shortened = 0.

Lower Crown

1. Select a strong, unshaded branch on the lower crown at about breast height; count the number of annual needle complements retained. The number may range from 1 up to 20 whorls.

2. Assign a number of 0, 2, or 4 for needle condition to each needle whorl as in item 4 for upper crown. All of these numbers plus the number of whorls will be summed. For example, a branch with 20 whorls each with a 4 rating would add to 80 plus 20 for number retained equals 100.

3. Assign a 0 or 1 for needle length from a general view of the lower crown.

4. Assign a 0 or 1 for branch mortality in the lower crown as is done with pines.

5. Add up all of the scores from upper and lower crown. Scores usually range from 0 to 90.

Incense Cedar:

The same score numbers apply to incense cedar but only general views of the inner and outer portions of the upper and lower crown can be obtained. It is very difficult to determine foliage age on this species.

Upper Crown

Retention inner crown.....0, 2, 4
Retention outer crown... .0, 2, 4
Condition inner crown.....0, 2, 4
Condition outer crown.....0, 2, 4

Lower Crown

Retention and condition scored the same as the upper crown.

Branch mortality for lower crown.....0, 1

Scores usually range from 0 to 33.

Black Oak:

Upper Crown

Foliage density.....0, 2, 4
Leaf Condition......0, 2, 4
Leaf Size...........0, 1

Lower Crown

Retention, Condition and leaf size scored the same.
Branch Mortality....0, 1
Scores range from 0 to 19.

Results - 1973

1) The amount of injury to tree species has been ranked in the following tables and figures in several ways: 1) Each species appears in a single table or figure. 2) The injury at each plot is presented with the least injury at the top of the list and most at the bottom. 3) The pines are classified into established categories: very severe, severe, moderate, slight, very slight and no injury. Because we have less experience with white fir, incense cedar and black oak, they have been categorized by indicating the percent of the total sample at each plot which falls into the first, second, third and fourth quarters of the score range observed at each plot. 4) The total number of trees in each sample is included in parentheses following the name of each plot.

The relative times of occurrence of the several species in the plots was: ponderosa pine - 8 plots; Jeffrey pine - 9 plots; sugar pine - 8 plots; white fir - 14 plots; incense cedar - 4 plots; and black oak - 14 plots.

Tables III-3, III-4 and III-5 compare the condition of ponderosa, Jeffrey and sugar pines at the plots where they occur. Figures III-7, III-8 and III-9 compare plots containing white fir, incense cedar and black oak. All of this data is on punch cards at present and a very simple program was written to obtain these simple classifications. It is difficult to make conclusive statements about these results until we have completed several statistical tests. This work is in progress.

We are presently keypunching the 1973 data from the sapling plots and will start soon on the 20 by 100 meter plots which represent different exposure and site aspects of a heavily damaged area centered between Rim Forest and Blue Jay.

Several conclusions can be drawn from these data: 1) The degree of injury to pines generally follows expected trends, namely, less injury at greater distances from the source of pollution. Where exceptions occur and it appears as if there is less injury to pines in some plots closer to the source (L.A. Basin), the answer may be that the plot was established where sanitation-salvage logging had recently removed very severe, severe and moderate injury trees, e.g. Camp Angelus. Future comparisons may have to account for the apparently higher oxidant tolerance of these "selected" populations.

2) Although conifers "store" the annual damage information in a static situation after maximum symptom development in September and October, black oak does not. In 1974, black oaks in all plots will be monitored for the first appearance of injury and two detailed evaluations will be made of all trees; the first in early August and the second at the time conifers are evaluated. The occurrence of this species in 14 plots may make it a more useful indicator of injury where sample size is adequate. Periodic photographs of foliage on selected trees will supplement this surveillance program.

3) Although some injury information is available from 6 plots in 1972, scoring procedures for white fir, incense cedar and black oak were not the same as in 1973. The 1973 data will provide the best baseline for all plots.

4) Mortality rates in comparable ponderosa pine plots between 1972 and 1973 was generally less than 3% and even less for Jeffrey pine. No oxidant-induced mortality was confirmed in any of the other tree species.

Progress in other smaller projects - 1973-74.

1) Saplings were harvested from greenhouses and outside control plots

which had received carbon-filtered air, ambient air inside and ambient air outside since August 1968. Radial growth between every internode was measured (cooperator Joe McBride) according to the Duff and Nolan technique. Data is being analyzed to determine direct effects of oxidant (known dose) on radial growth of saplings.

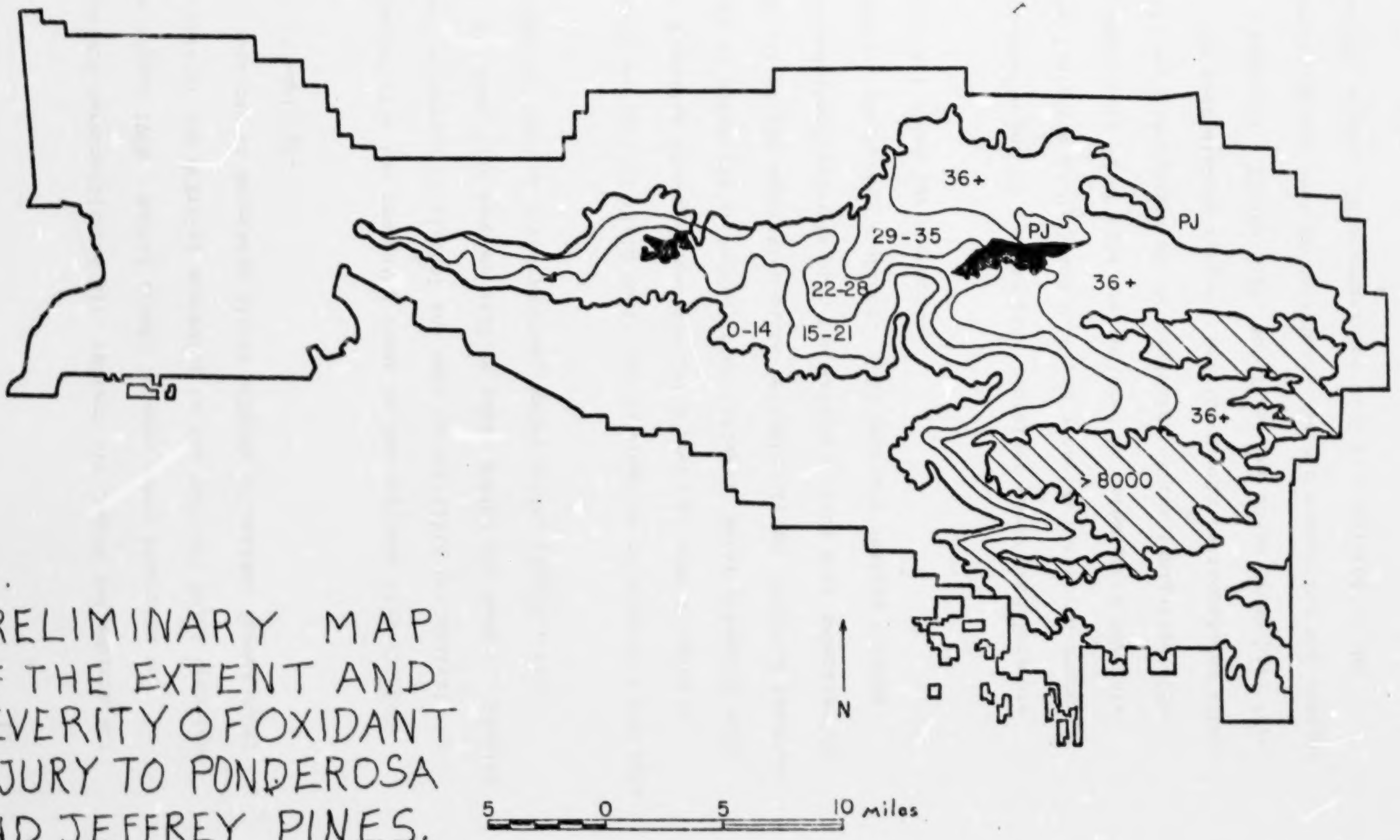
2) Needle samples from the remaining trees in the previous item (1) have been harvested, preserved in alcohol and sent to Corvallis for analysis by Dave Tingey. At least four samples will be taken during the summer. Samples will be analyzed for various carbohydrates, amino acids, phenols, etc.

3) Calibrations and initial field tests are in progress to prepare a pressure porometer for measuring stomatal function and a pressure bomb to measure water potential of ponderosa or Jeffrey pine foliage. Water potential will be measured at all of the vegetation plots periodically and stomatal function will be determined simultaneously at a few selected plots near telemetering weather and oxidant monitoring stations. Soil moisture sensing columns are available at all sites for comparison.

4) About 50 ponderosa and 50 Jeffrey pine container grown seedlings are currently being fumigated at 0.25 and 0.50 ppm ozone at the North Shore facility. An additional 50 of each are included as unfumigated controls. One third of all were inoculated at the beginning of the fumigation with *fomes annosus*, the root disease fungus. One third will be inoculated after 30-45 days of fumigation. Fields Cobb, Bob James and Johan Bruhn have furnished the inoculation and done inoculations. We are conducting the fumigation and evaluating injury. This experiment will be completed in the fall of 1974.

FIGURE III-6

SAN BERNARDINO NATIONAL FOREST (1974)


36+
29-35
PJ
PJ
36+
22-28
0-14
15-21
36+
>8000
N
5
0
5
10 miles

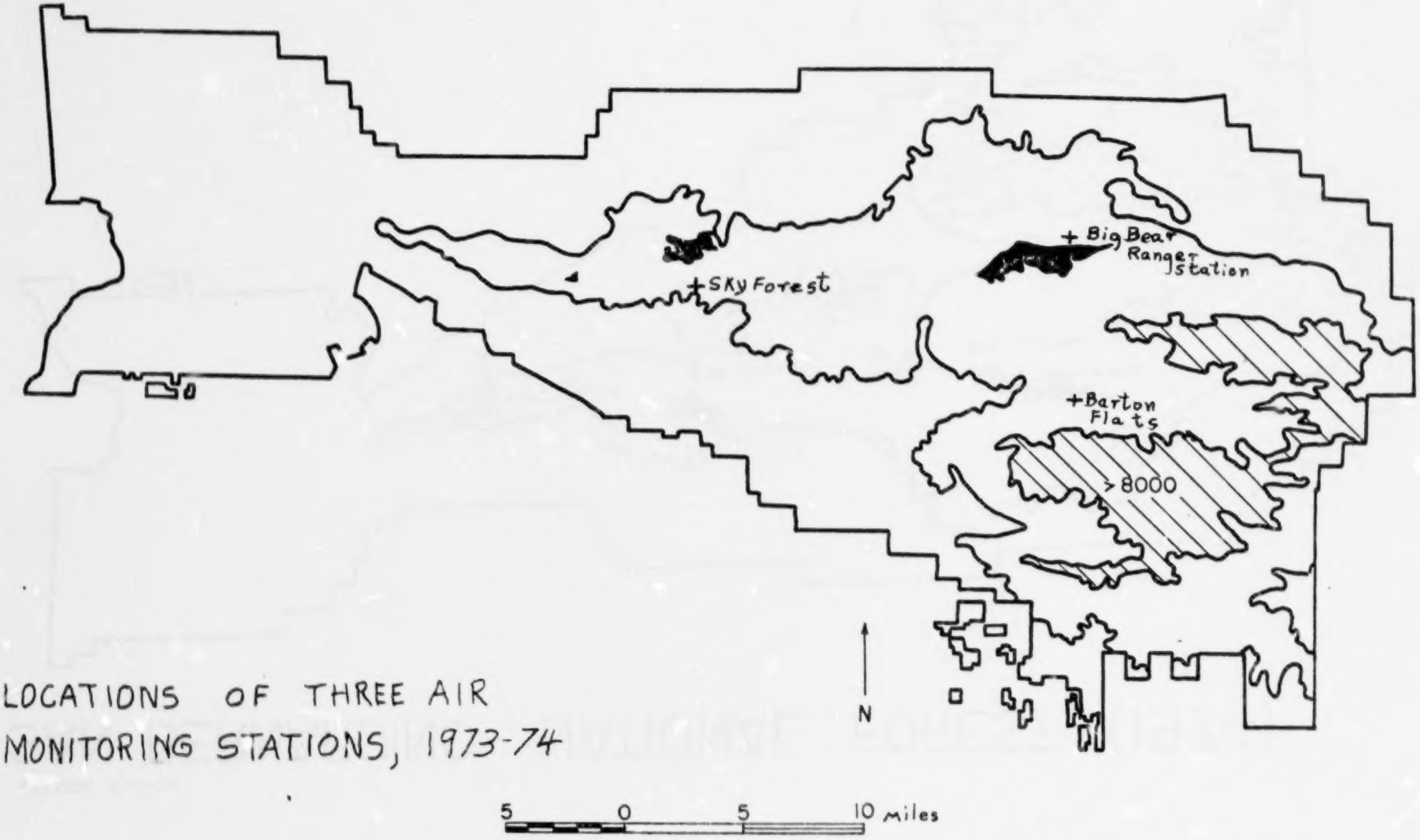
PRELIMINARY MAP
OF THE EXTENT AND
SEVERITY OF OXIDANT
INJURY TO PONDEROSA
AND JEFFREY PINES.

0-14 = VERY SEVERE AND SEVERE
15-21 = MODERATE
22-28 = SLIGHT
29-35 = VERY SLIGHT
36+ = NO VISIBLE INJU

41.

FIGURE III-1a

SAN BERNARDINO NATIONAL FOREST (1974)

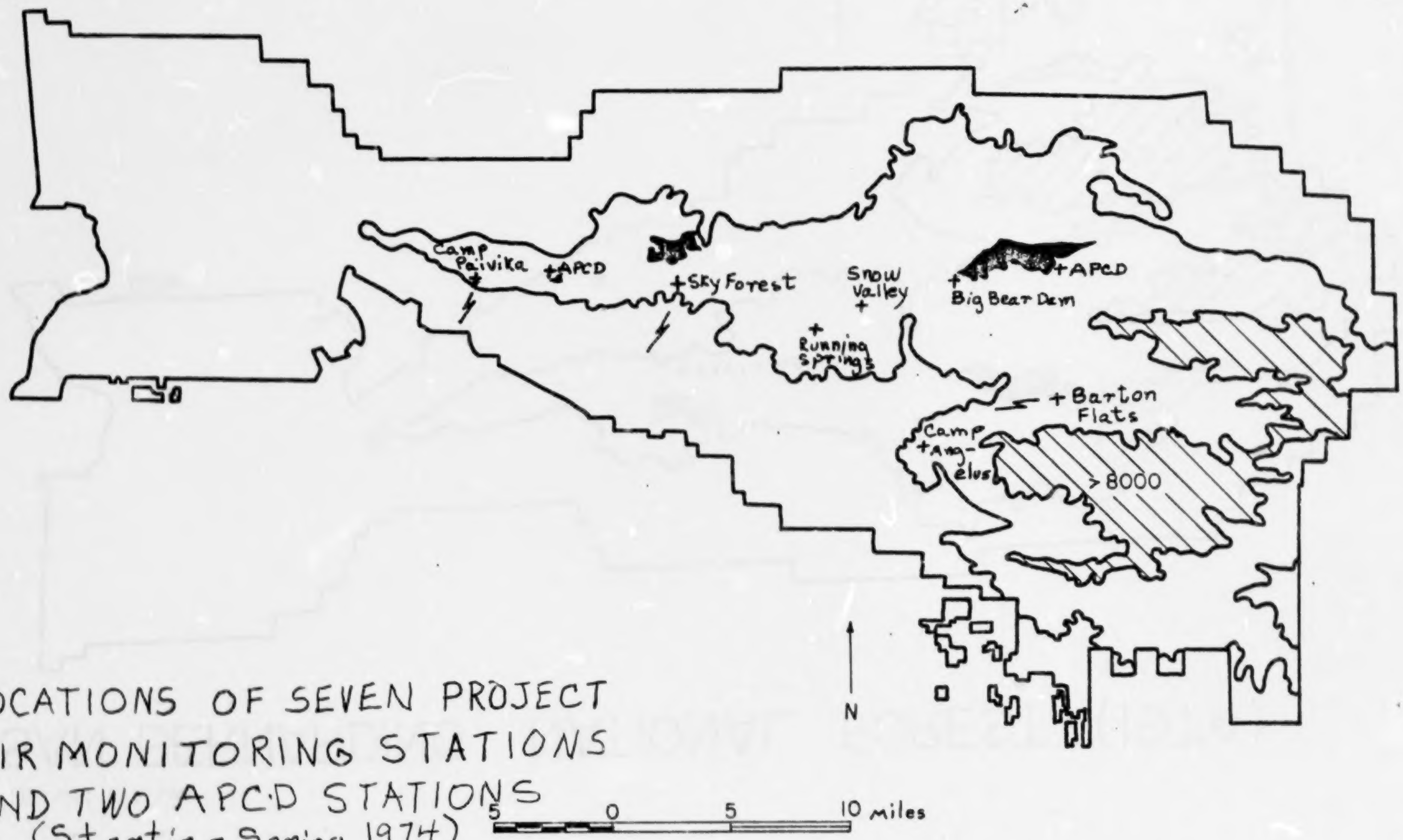

+ Sky Forest
+ Big Bear Ranger Station
+ Barton Flats
>8000
N
5
0
5
10 miles

LOCATIONS OF THREE AIR
MONITORING STATIONS, 1973-74

42.

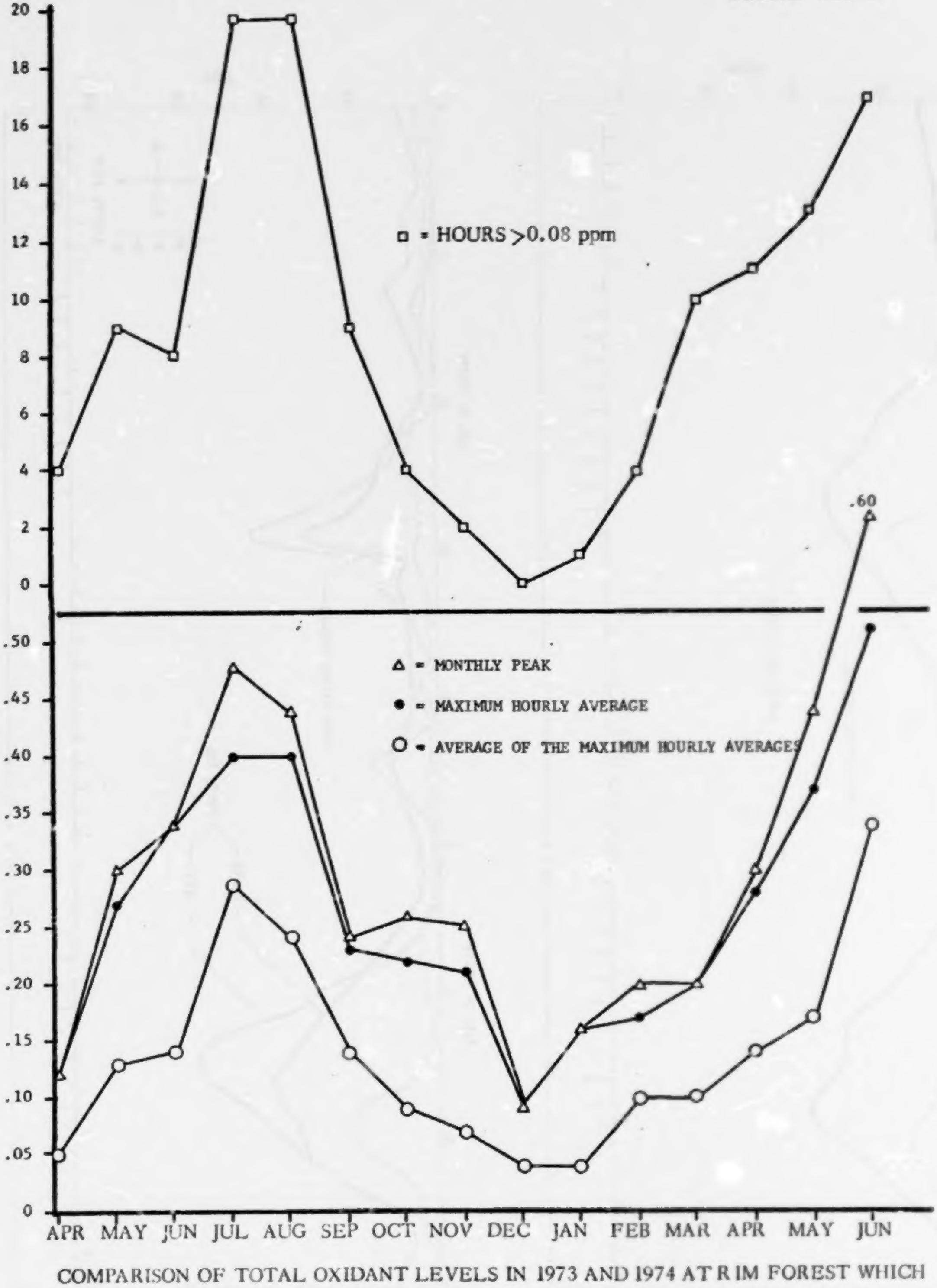
FIGURE III-1b

SAN BERNARDINO NATIONAL FOREST (1974)


Camp Paivika
APCD
Sky Forest
Snow Valley
Running Springs
Big Bear Dam
APCD
Barton Flats
Camp Ang-elus
>8000
N
5
0
5
10 miles

LOCATIONS OF SEVEN PROJECT
AIR MONITORING STATIONS
AND TWO APCD STATIONS
(Starting Spring 1974)
ϟ = telemetry

FIGURE III-2



COMPARISON OF TOTAL OXIDANT LEVELS IN 1973 AND 1974 AT RIM FOREST WHICH WAS REPLACED BY A NEW STATION AT NEARBY SKY FOREST AT THE END OF JULY 1973.

FIGURE III-3

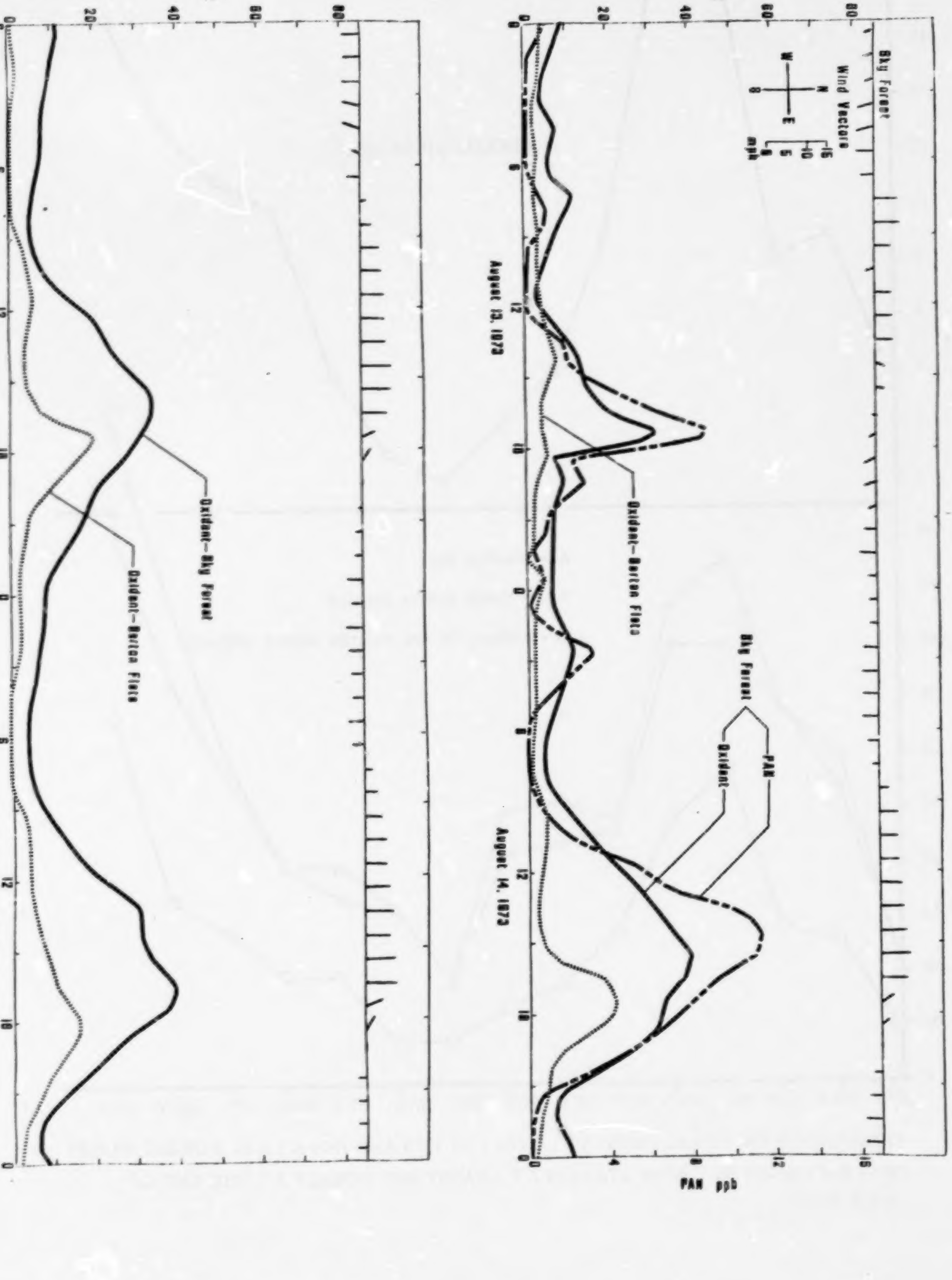

Big Forest
Wind Vectors
N
W
E
S
15
10
5
0
mph
pphm
80
60
40
20
0
PAN ppb
0
4
8
12
16
0
6
12
18
0
6
12
18
0
August 13, 1973
August 14, 1973
Oxidant—Barton Flats
Big Forest
PAN
Oxidant
August 15, 1973
August 16, 1973
Oxidant—Big Forest
Oxidant—Barton Flats
HOURS PDT

FIGURE III-4

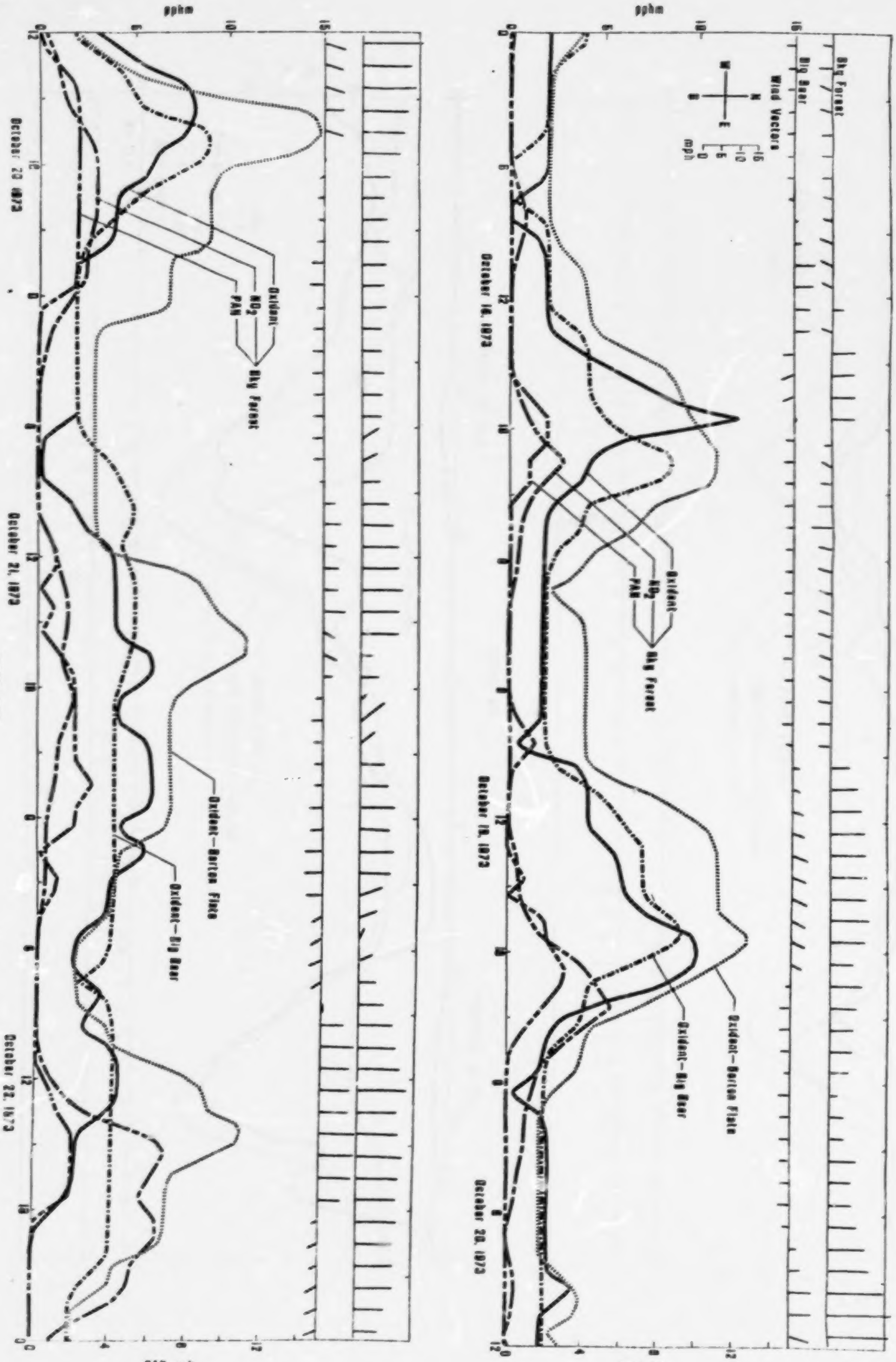

Big Forest
Big Bear
Wind Vectors
N
E
S
W
15
10
5
0
mph
pphm
0
5
10
15
PAN ppb
0
4
8
12
Oxidant
NO2
PAN
Big Forest
Oxidant—Barton Flats
Oxidant—Big Bear
October 18, 1973
October 19, 1973
October 20, 1973
October 21, 1973
October 22, 1973
6
12
18
HOURS PDT

FIGURE III-5

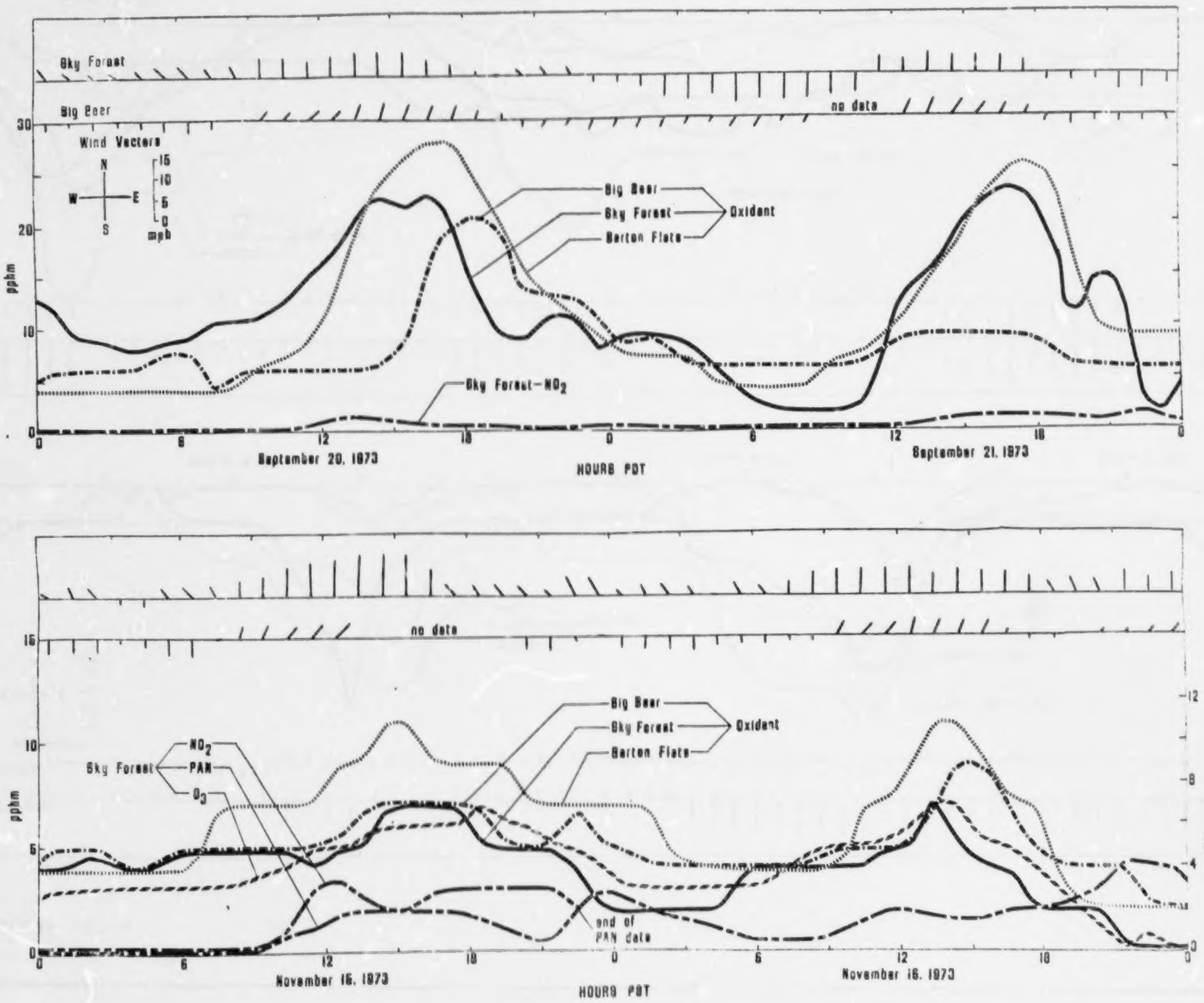

Sky Forest
Big Bear
no data
Wind Vectors
N
W
E
S
15
10
5
0
mph
pphm
30
20
10
0
Big Bear
Sky Forest
Barton Flats
Oxidant
Sky Forest—NO_2
6
12
18
September 20, 1973
September 21, 1973
HOURS PDT
16
no data
Sky Forest
NO_2
PAN
O_3
end of PAN data
November 16, 1973
November 16, 1973
PAN ppb
12
8
4

EXHIBIT III-1. A sample of the teletype printout from the shared telemetry network. Stations 11 and 12 are the property of the EPA project; Station 9 is a USFS Station with an EPA ozone sensor. Data is simultaneously recorded on magnetic tape. Remote stations have a strip-chart recorder backup.

```
USFS METEOROLOGICAL RESEARCH TELEMETRY NETWORK-RIVERSIDE,CA    7/ 2/74

ID  TIME DIR TEMP1 TEMP2 RAD HUM1 VOLT CURR OZONE TEMP3 HUM2 MPH MPH
          D    F     F    L    %    V    A    PPM    F    %   AVG MAX
```

Camp Paivika (a USFS station with an ozone sensor)

```
 9 19: 0 174  56.3  56.7-0.0  0.2 13.0 2.94 0.114  58.1 ****   9  13
11 19: 0 204  56.7  57.2-0.0  0.0 13.0 3.02 0.169 ***** ****   6   7
```

Sky Forest

```
USFS METEOROLOGICAL RESEARCH TELEMETRY NETWORK-RIVERSIDE,CA    7/ 2/74

ID  TIME DIR TEMP1 TEMP2 RAD HUM1 VOLT CURR OZONE TEMP3 HUM2 MPH MPH
          D    F     F    L    %    V    A    PPM    F    %   AVG MAX


 1 20: 0 356  71.1  71.1-0.2  0.0 11.4 2.83 ***** ***** ****   2   3
 2 20: 0 337  69.3  68.9-0.1 69.4 11.7 2.93 ***** ***** ****   4 ***
 3 20: 0  13  71.2  71.6-0.3 -0.2 11.4 3.04 ***** ***** ****   6   7
 4 20: 0 333  66.2  66.4-0.1  0.1 11.4 2.38 ***** ***** ****   5   6
 5 20: 1  17  63.5  63.9-0.1  0.0 11.4 3.73 ***** ***** ****   0   1
 6 20: 1  21  63.1  63.3-0.1  0.0 11.2 3.08 ***** ***** ****   7   9
 7 20: 1 253  54.9  54.7-0.1  7.3 11.4 2.87 ***** ***** ****   5   7
 8 20: 1 323  64.2  64.6-0.1  0.0 12.2 2.95 ***** ***** ****   0   1
 9 20: 1 179  55.9  54.9-0.1  0.2 13.0 2.93 0.084  55.8 ****  14  15
10 20: 2 323 -15.9  62.1-0.1  0.2 11.9 2.92 ***** ***** ****   2   4
11 20: 2 163  55.6  55.6-0.0  0.0 13.0 3.04 0.163 ***** ****   5   6
```

12 Barton Flats station in process of installation.

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1973-1974

Interaction Levels

(Listed Interactions)

	Organism	Tree	Community	Stand	Ecosystem
Climatic controls of oxidant concentrations and the extent and severity of oxidant injury to forest vegetation.	[1] II-1-3 II-15 II-1-13	II-1-A-13	II-2-2 II-2-3	II-2A-10a	II-3-2
Direct effects of oxidant injury to forest vegetation.	II-1-10	II-1-A-10b	II-2-8	II-2A-8a	II-3-1
Secondary effects of oxidant injury to forest vegetation.	II-1-20	II-1-A-24c	II-2-10 II-2-21	II-2A-8b II-2A-10b	II-3-7 II-3-8

[1] Specific interactions named in Tables II-1, II-1A, II-2, II-2A and II-3.

TABLE III-1. A summary of the specific interactions which are the immediate responsibility of Paul Miller and Henry Milligan along with those in which there is a cooperative participation.

TABLE III-2

Summary of Oxidant Air Monitoring
April to December 1973
San Bernardino Mountains, at Rim Forest, Sky Forest, Barton Flats and Big Bear Ranger Station

Stations and Month	Maximum Hourly Average	Average of Maximum Hourly Averages	Hours/day above 0.08 ppm	Monthly Peak	Day of Peak
April 73					
Rim Forest	.12	.05	4	.12	28
May 73					
Rim Forest	.27	.13	9	.30	10
Barton Flats	.24	.15	7	.26	29
June 73					
Rim Forest	.34	.14	8	.34	28
Barton Flats	.26	.16	6	.30	27
July 73					
Rim Forest	.40	.29	19	.48	25
Barton Flats	.31	.22	11	.33	25
Aug. 73					
Rim Forest 1-5	.44	.27	19	.48	1
Sky Forest 6-31	.40	.24	13	.44	16
Barton Flats	.23	.13	6	.27	15
Big Bear R. S.	.17	.10	3	.19	28
Sept. 73					
Rim Forest	Station closed August 5, replaced by Sky Forest				
Sky Forest	.23	.14	9	.24	21
Barton Flats	.28	.18	9	.28	20
Big Bear R. S.	.21	.10	7	.23	29
Oct. 73					
Sky Forest	.22	.09	4	.26	12
Barton Flats	.22	.11	6	.24	5
Big Bear R. S.	.19	.08	3	.24	8
Nov. 73					
Sky Forest	.21	.07	2	.25	8
Barton Flats	.17	.09	3	.17	8
Big Bear R. S.	.12	.06	0.4	.14	9
Dec. 73					
Sky Forest	.09	.04	0	.09	17
Barton Flats	Deactivated for winter				
Big Bear R. S.	Deactivated for winter				

TABLE III-3

Ponderosa Pine--1973
Injury Score Ranges

	0-8 Very Severe	9-14 Severe	15-21 Moderate	22-28 Slight	29-35 Very Slight	36+ No Visible Injury
Camp Angelus (69)	2.9	7.2	21.7	37.6	21.7	8.7
Tunnel 2 (73)	4.1	16.4	46.6	23.3	6.8	2.7
Barton Flats (178)	11.2	20.8	26.4	15.1	12.3	14.0
Dogwood (92)	8.7	18.4	31.5	34.8	3.3	3.3
Breezy Point (72)	6.9	34.7	38.9	15.3	2.8	1.4
Camp Paivika (91)	7.2	27.8	42.3	16.4	6.1	0.0
Camp O'Ongo (60)	10.0	35.0	43.3	8.3	3.3	0.0
UC Conf.Ctr. (64)	10.9	42.2	31.3	10.9	4.7	0.0
Sky Forest (120)	10.8	52.5	30.0	5.8	0.8	0.0

TABLE III-4

Jeffrey Pine--1973
Injury Score Ranges

	0-8 Very Severe	9-14 Severe	15-21 Moderate	22-28 Slight	29-35 Very Slight	36+ No Visible Injury
Holcomb Valley (168)	0.0	0.0	2.9	1.2	8.9	86.9
Heart Bar (112)	0.9	0.0	0.9	5.3	13.4	79.4
Sand Canyon (62)	0.0	0.0	1.6	9.6	22.6	66.1
NE Green Valley (64)	0.0	0.0	4.7	26.6	29.7	39.1
Green Valley Cr (67)	0.0	11.9	53.7	16.4	10.4	7.4
Bluff Lake (137)	0.7	5.8	22.6	18.2	21.1	31.4
Snow Valley (98)	1.0	9.1	40.8	35.7	9.1	4.1
Barton Flats (59)	6.8	18.6	32.2	22.2	15.3	5.1
Camp Oceola (125)	8.0	28.0	26.4	9.6	11.2	16.8
Schneider Cr. (112)	11.6	19.6	10.7	8.9	12.5	36.6

TABLE III-5

Sugar Pine--1973
Injury Score Ranges

	0-8 Very Severe	9-14 Severe	15-21 Moderate	22-28 Slight	29-35 Very Slight	36+ No Visible Injury
Camp O'Ongo (1)	0.0	0.0	0.0	0.0	0.0	100.0
Camp Paivika (1)	0.0	0.0	0.0	0.0	0.0	100.0
Dogwood (3)	0.0	0.0	0.0	0.0	0.0	100.0
Schneider Cr. (2)	0.0	0.0	0.0	0.0	50.0	50.0
Tunnel 2 (5)	0.0	0.0	0.0	0.0	40.0	60.0
Green Valley Cr. (11)	0.0	0.0	0.0	27.3	27.3	45.4
Camp Angelus (5)	0.0	0.0	20.0	0.0	20.0	60.0
Sky Forest (15)	0.0	6.6	0.0	13.3	20.0	60.0

RANGES OF OXIDANT DAMAGE SCORES FOR

BLACK OAK AND DISTRIBUTIONS WITHIN EACH RANGE (PERCENT) - 1973

FIGURE III-9

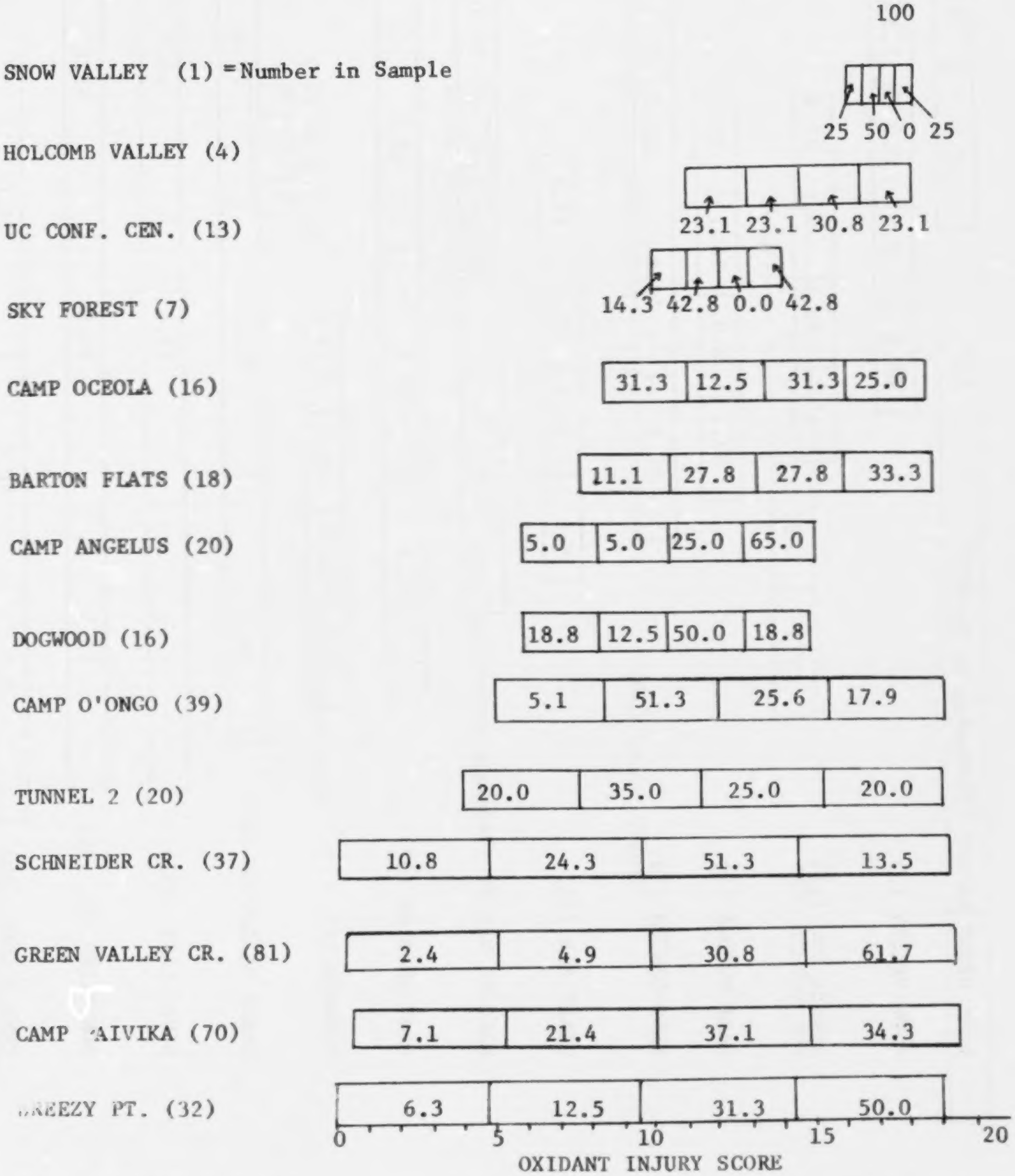


FIGURE III-7

RANGES OF OXIDANT DAMAGE SCORES FOR WHITE FIR AND DISTRIBUTIONS WITHIN EACH RANGE (PERCENT) - 1973

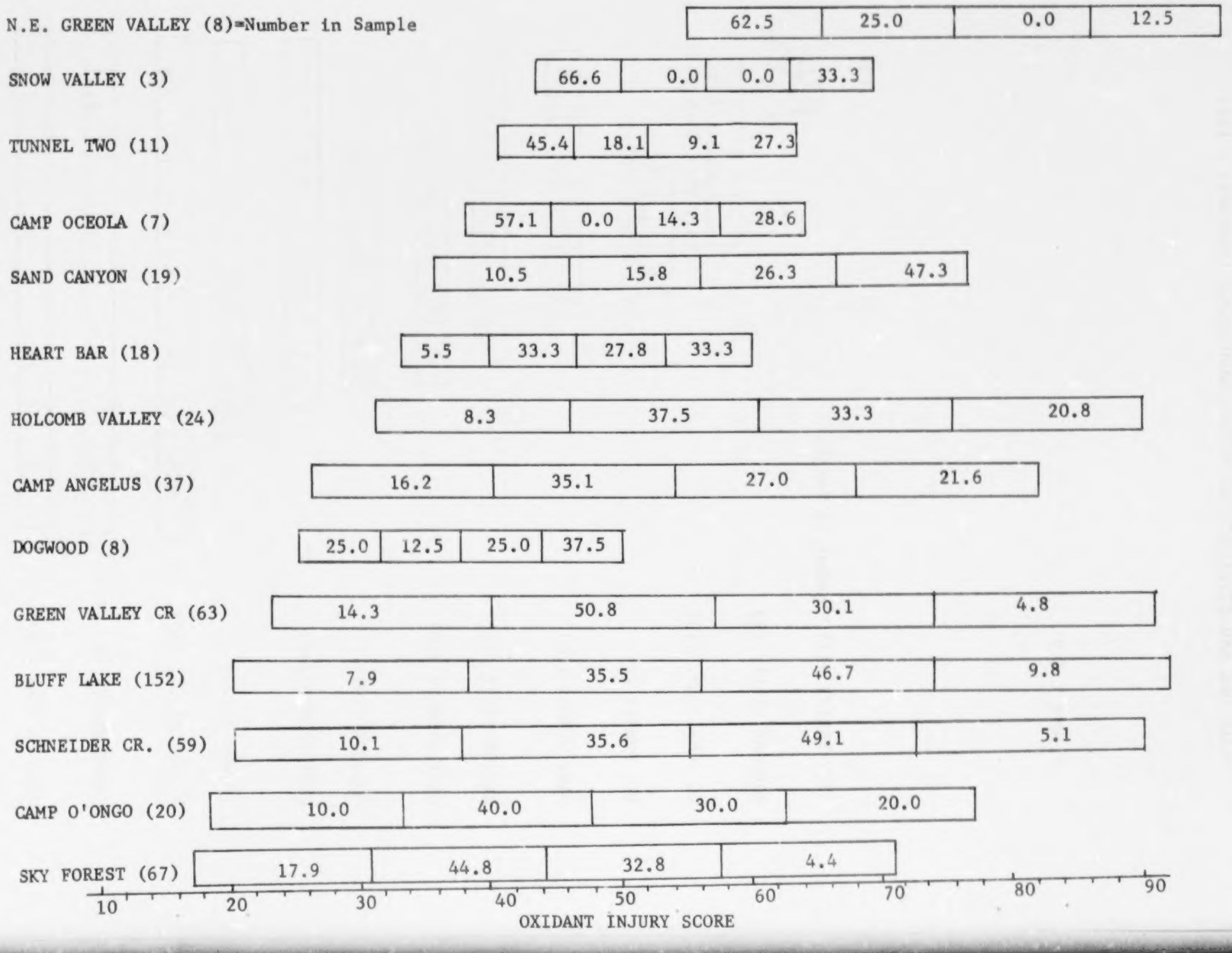
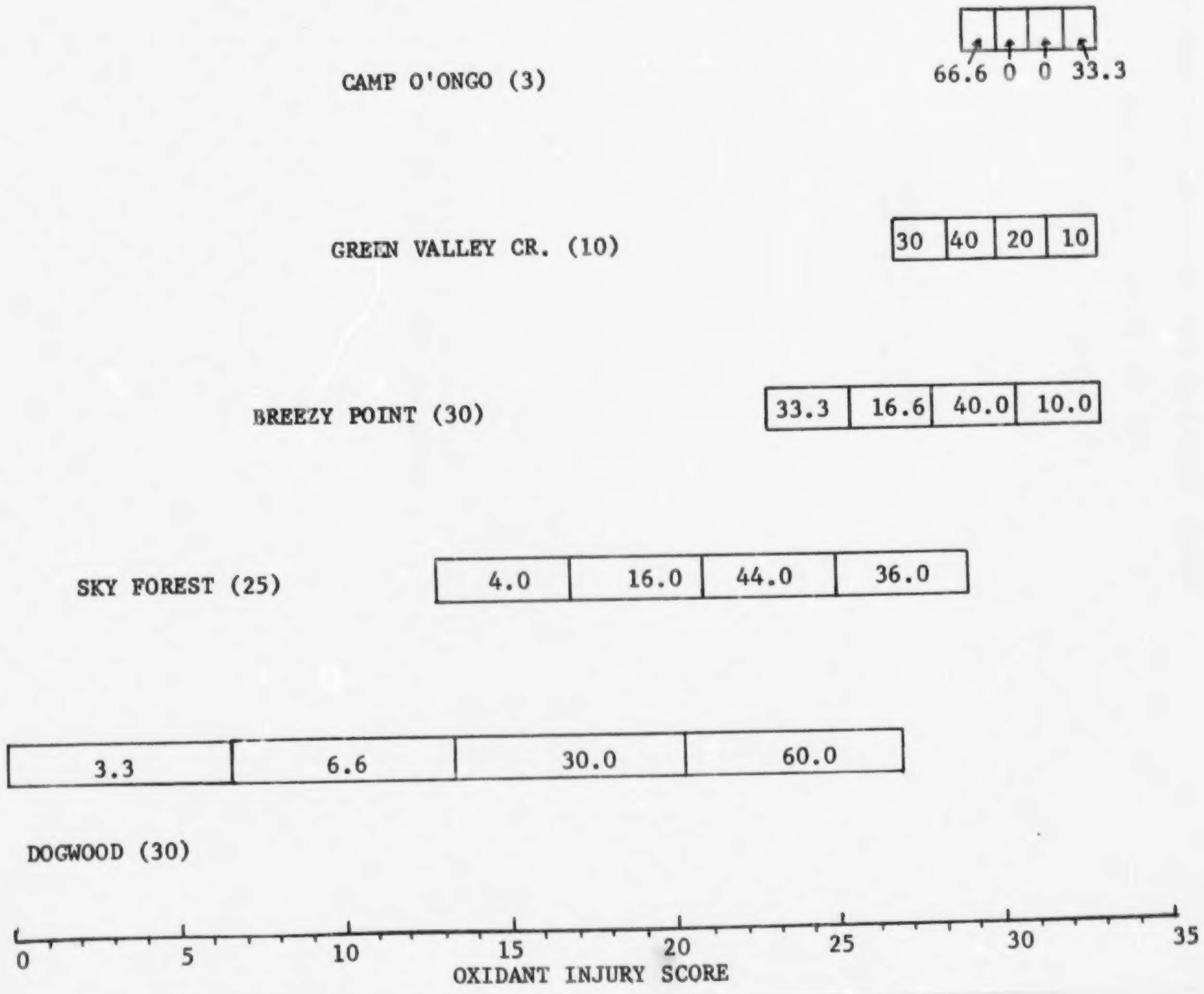


FIGURE III-8

RANGES OF OXIDANT DAMAGE SCORES FOR INCENSE CEDAR AND DISTRIBUTIONS WITHIN EACH RANGE (PERCENT) - 1973



III-B

STUDY OF EFFECTS OF OXIDANT AIR POLLUTANTS ON A MIXED CONIFER FOREST ECOSYSTEM

Annual Report of the Vegetation Sub-Committee
for the Fiscal Year Ending
June 15, 1974

Principal Investigator
Joe R[illegible]ride

University of California
Berkeley, California 94720

INTRODUCTION

The Vegetation Subcommittee was primarily involved in initiating studies of (1) the effect of soil moisture and soil temperature on tree growth (organism level interaction 25), effect of ozone on tree growth (tree level interaction 10aDG), and (2) logging modification of community structure (plant succession interaction 9) during the year ending June 15, 1974. In addition to these particular studies, the Vegetation Subcommittee also participated in several other studies (tree level interaction 10b; community level interactions 12, 14, 15, 16, 19; stand level interactions 6b, 6c, 8a, 8b, 10a, 12b, 15a, 15b, 16a, 16b, 19; plant succession interactions 1,2,4, 5,6) by the measurement of certain vegetation parameters on the permanent study plots established for this project. This report will review the progress of the three primary studies of the Vegetation Subcommittee and the work completed in the measurement of vegetation on the permanent study plots.

EFFECT OF SOIL MOISTURE AND SOIL TEMPERATURE ON TREE GROWTH

The objective of this study is to determine the effect of soil moisture and soil temperature on tree growth. During the past year a network of soil moisture and soil temperature monitoring stations were established in the forest by the Soils Subcommittee. These stations, located on the 18 permanent plots, will provide information which can be correlated with the growth of trees on the plots. The Vegetation Subcommittee measured all trees of 10 cm DBH during the past year (this data is discussed in a following section entitled "Establishment of Permanent Study Plots") to provide baseline information for a tree growth study. Periodic remeasurement of the trees will be used to determine the amount of growth occurring on each plot. A regression analysis will be run to determine the relationships between growth, soil moisture, and soil temperature.

During the past year an effort was made to correlate radial tree growth with precipitation. It was anticipated that this investigation would determine the relative sensitivity of radial tree growth to variations in precipitation from year to year. In this study, average annual ring width of 160 *Pinus ponderosa* trees occurring on a Forest Service study plot near the Dogwood permanent plot were correlated with annual precipitation, seasonal precipitation (September - August) and calculated evapotranspiration. The period covered in the study was 1893 to 1971. The results of the analysis showed a very poor correlation between radial growth and the three approximations of moisture available for tree growth (Table 1).

Table 1. Correlations between radial tree growth and annual precipitation, seasonal precipitation (September - August), and potential evapotranspiration.

Independent Variable		R
Annual Precipitation	$Y - 1.0259 - 0.005x$	-0.0820
Seasonal Precipitation	$Y = 0.2552 - 0.00004x$	-0.0069
Calculated Evapotranspiration	$Y = 11.2079 - 0.4510x$	-0.6102

The poor correlations may be due to (1) a low level of sensitivity on the part of the trees or (2) irregularities in production of annual rings. The latter possibility is being investigated through a careful re-examination of each tree core.

EFFECT OF OZONE ON TREE GROWTH

The purpose of this investigation is to determine the effect of ozone on tree growth. An initial study, completed in 1973, attempted to relate radial tree growth to ozone caused crown damage. Tree cones from the 160 trees described above were used in this study. Correlation between current year ring width and current year smog injury score was slight (Table 2). This poor correlation suggested that radial growth is not immediately affected by a reduction in the capacity of the tree to photosynthesize. Correlation between current years growth and the average smog injury score for the preceeding three years was much higher (Table 2). This result was interpreted as suggesting that annual radial growth can occur through the utilization of surplus carbohydrates within the plant. Once these are exhausted radial growth will reflect the inability of the smog damaged crown to do photosynthesis. The investigation of the effect of ozone on radial growth is being expanded in 1974 and 75 to include a study of the quantity and distribution of soluble carbohydrates in trees exhibiting different smog injury symptoms.

Table 2. Correlations between radial growth and smog injury score

Independant Variable		r
Current year smog injury score (1971)	$Y = 0.052 + 0.005x$	0.381
Average smog injury score (1969-71)	$Y = 0.020 + 0.007x$	0.579

LOGGING MODIFICATION OF COMMUNITY STRUCTURE

The current logging practice in the San Bernardino Mountains can be described as a sanitation-salvage program. Under this practice trees are selected for cutting primarily on the basis of risk to insect attack. Some consideration of air pollution damage is also given when timber is marked for cutting.

During the summer of 1973 timber was marked for cutting by the Forest Service in the Barton Flat area. The Vegetation Subcommittee made a reconnaissance of the sale area to determine the potential impact of the logging operation on the structure of the forest community. The reconnaissance involved the measurement and classification of trees along a series transecting across the timber sale area. The results of this study have not been summarized. Additional field sampling is planned during the summer of 1974 to provide a larger sample from additional areas in the San Bernardino Mountains.

MEASUREMENT OF VEGETATION ON PERMANENT PLOTS

Eighteen permanent plots have been established in the study area. The layout of these plots and the location of trees on the plots has been described by Dr Paul Miller. The Vegetation Subcommittee collected data on plants in the tree, shrub, and herbaceous layers during the summer of 1973. Tree layer data was used to calculate number of individuals, species composition, density, and basal area (Table 3). Shrub layer data was used to determine species composition, density and cover (Table 4). Herbaceous layer plants were enumerated by plot (Table 5). This data will serve as a basis for many studies on the plots.

The Vegetation Subcommittee also prepared tree location maps for the permanent plots. These maps will provide each investigator an accurate display of tree locations which can be useful in selection locations for particular studies. The maps also present tree identification number, tree diameter, and smog injury score as measured in 1973. An example of these maps is included in Appendix I.

Special plots were also established by the Entomology Sub-Committee to study bark beetles (organism level interactions 18, 19; community level interactions 4, 14, 15, 19; stand level interactions 15a, 15b, 19a; plant succession interaction 5). The Vegetation Subcommittee measured tree layer species on these plots in 1973 and will complete a survey of shrub layer and herbaceous layer species in 1974.

Table 3. Tree layer data from permanent plots

Plot		Species*											
		PP	SP	IC	WF	JP	BO	JO	CL	QW	CP	QC	SS
Schnieder Creek	# trees[1]		2		40	20					1	26	
	spp. comp.[2]		1		25	12					1	16	
	density[3]		2.8		55.6	27.8					1.4	36.1	
	basal area[4]		1.79		11.24	17.97					.27	1.68	
Bluff Lake	# trees				152	132							157
	spp. comp.				51	44							53
	density				214.5	186.3							221.5
	basal area				13.53	28.20							13.65
Sand Canyon	# trees		13	28		61		3	43				
	spp. comp.		7	15		49		2	34				
	density		16.5	33.6		56.2		2.7	39.6				
	basal area		7.02	10.60		15.39		1.25	2.19				
Camp Angeles	# trees	70	5		37		20						
	spp. comp.	53	4		28		15						
	density	111.8	7.9		58.7		31.7						
	basal area	26.29	7.39		8.94		7.99						
Barton Flats	# trees	139				86	16			8			
	spp. comp.	56				34	6			3			
	density	200.1				123.8	23.0			11.6			
	basal area	16.87				10.21	5.99			0.56			
Heart's Bar	# trees		2		18	152			1				
	spp. comp.		1		10	88			1				
	density		1.7		15.3	129.7			0.7				
	basal area		0.28		3.20	11.70			0.01				

*See attached list for species names

[1] Number of trees on the plot

[2] Percent species composition on the basis of number of trees

[3] Number of trees/hectare

[4] Basal area in square meters/hectare

Table 3. Tree layer data from permanent plots (continued)

Plot		Species										
		PP	SP	IC	WF	JP	BO	JO	CL	QW	CP	DW
Tunnel Two	# trees[1]	73	5		11		20				2	
	spp. comp.[2]	65	4		9		18				1	
	density[3]	121.7	8.3		18.3		33.3				3.3	
	basal area[4]	19.42	.65		.85		2.06				.91	
Breezy Point	# trees	71		30			31			1		
	spp. comp.	53		22			23			1		
	density	236.7		100.0			103.3			3.3		
	basal area	28.10		11.86			4.08			0.04		
Sky Forest	# trees	104	15	25	67		7					4
	spp. comp.	43	6	10	28		2					1
	density	144.4	20.8	34.7	93.1		9.7					5.6
	basal area	28.38	.60	4.10	3.85		2.21					0.08
Camp O'ongo	# trees	46	1	3	20		39					
	spp. comp.	37	1	2	16		31					
	density	90.2	2.0	5.9	39.2		76.5					
	basal area	14.52	.72	1.53	6.00		4.80					
Green Valley Creek	# trees		11	10	62	39	82			1		
	spp. comp.		4	4	26	16	35			1		
	density		12.2	11.1	68.9	43.3	91.1			1.1		
	basal area		2.93	1.63	4.94	12.20	4.70			0.02		
Dogwood	# trees	85	3	29	8		1.5					
	spp. comp.	61	2	21	6		11					
	density	168.4	5.9	58.3	16.7		29.7					
	basal area	15.96	.20	4.55	0.40		3.59					

Table 3. Tree layer data from permanent plots (continued)

		Species									
Plot		PP	SP	IC	WF	JP	BO	JO	CL	QW	CP
NE Green Valley	# trees[1]				8	65					
	spp. comp.[2]				10	89					
	density[3]				14.8	120.4					
	basal area[4]				1.05	35.00					
Snow Valley II	# trees				3	99	1				
	spp. comp.				2	96	1				
	density				3.9	129.4	1.3				
	basal area				1.30	21.56	.16				
U.C. Conference Grounds	# trees	65					13				
	spp. comp.	83					16				
	density	309.5					61.9				
	basal area	44.76					1.08				
N.W. Pavicka	# trees	98	1				70				
	spp. comp.	57	1				41				
	density	217.8	2.2				155.6				
	basal area	24.11	0.03				6.32				
Camp Osceola	# trees	33			7	92	16				
	spp. comp.	22			4	62	10				
	density	68.7			14.6	191.7	33.3				
	basal area	10.81			.45	29.33	3.82				
Holcomb Valley	# trees				24	168	4		5		
	spp. comp.				11	83	1		2		
	density				27.6	193.1	4.6		5.7		
	basal area				3.46	22.07	.21		0.13		

Tree Species on the Permanent Plots

Symbol	Species
PP	Pinus ponderosa
SP	Pinus lambertiana
IC	Libocedrus decurrens
WF	Abies concolor
JP	Pinus jeffreyii
BO	Quercus kelloggii
JO	Juniperus occidentalis
CL	Cercocarpus ledifolius
QW	Quercus wislizenii
CP	Pinus coulteri
QC	Quercus chrysolepis
DW	Cornus nuttallii
SS	Salix spp.

Table 4. Shrub layer data from permanent plots

PLOT	SPECIES*	FREQUENCY	DENSITY/100 m	% COVER	RELATIVE % COVER
Breezy Point	QuCh	1/5	0.2	.3	100.
Camp Angeles	AmCa	5/5	9.6	8.9	98.8
	QuCh	3/5	0.4	.1	1.2
Camp O'Ongo	AmCa	2/5	1.6	.5	1.8
	CeIn	4/5	2.9	2.1	7.9
	RhCa	1/5	0.1	.01	.04
	RiNe	5/5	15.9	8.2	30.4
	RiRo	5/5	13.4	16.2	59.9
Camp Osceola	AmCa	3/5	1.1	1.9	72.9
	CeCo	2/5	0.3	.7	25.1
	ChVi	1/5	0.1	.05	2.0
Dogwood	No Shrubs				
Hearts Bar	AmCa	5/5	0.7	0.7	3.5
	AmPa	2/5	0.2	0.04	0.2
	ArPa	5/5	4.7	6.5	34.4
	ArTr	1/5	0.2	0.09	0.5
	CeCo	5/5	5.0	8.4	44.0
	ChNa	5/5	1.0	0.3	1.8
	GuMi	5/5	4.8	1.9	9.7
	QuCh	1/5	0.05	0.08	0.4
	RoCa	1/5	0.05	0.01	0.05
	SaLu	4/5	0.3	0.9	4.8
	TeCa	5/5	0.6	0.1	0.6
Holcomb Valley	ArPa	5/5	1.8	4.0	19.8
	ArTr	5/5	7.8	4.9	24.3
	CeCo	5/5	7.2	10.8	53.9
	ChVi	1/5	0.07	0.03	0.15
	RiCe	1/5	0.14	0.2	0.99
	SyPa	2/5	0.37	0.2	0.88
NE Green Valley	ArPa	5/5	3.7	6.1	17.2
	CaCh	5/5	3.1	4.1	11.4
	CeCo	5/5	15.9	25.1	70.1
	ChNa	4/5	1.1	0.48	1.3
NW Pavieka	No Shrubs				
Sand Canyon	AmPa	2/5	0.2	2.0	11.0
	ArPa	5/5	3.4	8.0	44.0
	CeCo	5/5	4.6	4.9	26.8
	ChNa	4/5	0.7	1.7	0.9
	GuMi	3/5	0.9	0.25	1.4
	SyPa	5/5	6.7	2.4	13.0
	TeCa	5/5	1.9	0.49	2.8
	ArTr	1/5	0.06	0.04	0.2
Schnieder Creek	AmCa	5/5	1.7	4.9	100.0
Sky Forest	No Shrubs				

Table 4 (Continued) Shrub layer data from permanent plots

PLOT	SPECIES	FREQUENCY	DENSITY/100 m	% COVER	RELATIVE % COVER
Snow Valley II	ArPa	5/5	6.6	11.1	38.7
	CeCo	5/5	9.3	17.3	60.7
	ChNa	3/5	0.4	0.2	0.6
	SyMo	1/5	0.08	0.008	0.03
Tunnel Two	ArPr	5/5	8.0	7.99	88.4
	CeIn	3/5	0.5	0.13	1.5
	CeLe	1/5	0.3	0.07	0.81
	QuCh	4/5	0.5	0.84	9.3
U.C.Conf.Grnd.	ArPr	2/5	0.57	1.24	100.0
Barton Flats	AmCa	3/5	0.35	0.23	24.0
	QuCh	1/5	0.17	0.036	3.7
	RiRo	3/5	0.52	0.65	67.9
	RoCa	1/5	0.09	0.042	4.4
Bluff Lake	ArPa	2/5	0.17	0.29	1.9
	CeCo	5/5	10.9	15.1	98.1
Green Valley Creek	AmCa	5/5	1.67	1.53	22.5
	CeCo	5/5	1.53	4.07	59.9
	CeIn	1/5	0.07	0.04	0.59
	QuCh	1/5	0.07	0.06	0.88
	RiNe	4/5	1.33	1.09	16.1

* See attached list for species names.

Shrub Species in the San Bernardino Mountains

Symbol	Species
AmCa	Amorpha californica
AmPa	Amelanchier pallida
ArPa	Arctostaphylos patula
ArPr	Arctostaphylos pringlei
ArTr	Artemisia tridentata
CaCh	Castanopsis chrysophylla
CeCo	Ceanothus cordulaturs
CeIn	Ceanothus integerrimus
CeLe	Cercocarpus ledifolius
ChNa	Chrysothamnus nauseosus
ChVi	Chrysothamnus viscidiflorus
GuMi	Gutierrezia microcephala
QuCh	Quercus chrysolepis
RhCa	Rhamnus californica
RiCe	Ribes cereum
RiNe	Ribes nevadense
RiRo	Ribes roezlii
RoCa	Rosa californica
SaLu	Salix lutea
SyMo	Symphoricarpos mollis
SyPa	Symphoricarpos parishii
TeCa	Tetradymia canescens

Table 5. Herbaceous species occurring on the permanent plots

Species Symbol	Species	Plot*																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
AC MI	Achillea lanulosa						X	X	X						X		X		
AG RE	Agoseris retrorsa		X		X			X	X		X	X							X
AG IN	Agropyron intermedium			X												X			
AG EX	Agrostis exarata						X												
AG LE	Agrostis lepida									X									
AN DI	Antennaria dimorpha																		X
AR REC	Arabis rectissima	X			X						X				X		X		
AR REP	Arabis repanda												X	X					
AR SP	Arabis sparsiflora var. arcuata						X												
AR CA	Arceothobium campylopodom						X												
AR DO	Artemisia douglasiana		X																
AR DR	Artemisia dracunculus		X		X	X		X											
AR LU	Artemisia ludoviciana				X	X	X	X									X		
AS ER	Asclepias eriocarpa		X	X															
AS LE	Astragalus leucolobus										X				X		X		
BL CR	Bloomeria crocea	X	X						X		X	X							X
BR PU	Brodiaea pulchella	X	X					X	X									X	
BR CA	Bromus carinatus	X	X	X				X	X			X				X	X	X	X
BR OR	Bromus orcuttianus var. hallii		X	X							X		X	X		X			X
BR RI	Bromus rigidis		X																
BR TE	Bromus tectorum	X	X	X	X	X	X	X	X		X	X	X						X
BO GR	Bouteloua gracilis				X														
CA IN	Calochortus invenustus										X								
CA PA	Calyptridium parryi					X													
CA UM	Calyptridium umbellatum						X												
CA AL	Carex alma									X									
CA BR	Carex brevipes			X			X												
CA FR	Carex fracta						X												
CA MU	Carex multicaulis	X					X	X	X					X		X			X
CA OC	Carex occidentalis																X		
CA MA	Castilleja martinii					X							X		X				
CA MI	Castilleja miniata						X												
CA AM	Caulanthus am plexicaulis	X					X				X		X			X			
CAU MA	Caulanthus major					X							X						
CH SA	Chaenactis santolinoides					X					X		X	X	X				X

Table 5. Herbaceous species occurring on the permanent plots (continued)

Species Symbol	Species	Plot*																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
CH FR	Chenopodium fremontii														X			X	
CH ME	Chimaphila menziesii													X					
CI CA	Cirsium californicum							X											X
CI DR	Cirsium drummondii									X									
CI VU	Cirsium vulgare																	X	
CL RH	Clarkia rhomboidea		X						X									X	X
CO CH	Collinsia childii		X						X									X	
CO GR	Collomia grandiflora		X						X										
CO FU	Convolvulus fulcratus	X						X	X		X	X			X	X	X		X
CO NE	Cordylanthus nevenii			X							X		X	X					
CO FB	Corethrogyne filaginifolia var. brevicula		X	X	X	X		X			X		X				X		X
CO FS	Corethrogyne filaginifolia var sessilis	X																X	
CR AF	Cryptantha affinis								X										
CR MI	Cryptantha micrantha				X														
CR SI	Cryptantha simulans	X		X			X				X		X	X	X				X
DE EL	Deschampsia elongata						X												
EL GL	Elymus glaucus	X	X	X			X	X		X	X	X				X		X	X
ER DE	Eriastrum densiflorum var. austromentanum							X			X			X					
ER SP	Eriastrum sapphirinum				X														
ER BR	Erigeron breweri var. porphyreticus				X	X									X		X		
ER DI	Erigeron divergens							X											
ER FO	Erigeron foliosus	X	X	X				X	X		X	X		X	X			X	X
ER PA	Eriogonum parishii				X	X													
ER DA	Eriogonum davidsonii	X									X								
ER SA	Eriogonum saxatile	X									X			X					
ER UM	Eriogonum umbellatum var. stellatum			X			X				X			X					
ER WR	Eriogonum wrightii var. subscaposum				X	X	X	X						X	X		X		
ER CO	Eriophyllum confertiflorum				X						X			X	X				X
ER LA	Eriophyllum lanatum var. abovatum	X					X				X					X			
ER CA	Erysimum capitatum	X	X	X	X	X	X	X	X		X		X	X	X	X	X		
EU PA	Euphorbia palmeri				X	X	X	X			X				X		X		
FE RU	Festuca rubra							X											
FE UI	Festuca I		X																X
FE UT	Festuca II																		X
GA AN	Galium angustifolium var. pinetorum							X											

Table 5. Herbaceous species occurring on the permanent plots (continued)

-3-

Species Symbol	Species	Plot* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
GA AP	Galium aparine		X						X									X	
GA NO	Galium nuttallii var. ovalifolium		X					X	X										X
GA PA	Galium parishii				X	X											X		
GA NU	Gayophytum nuttallii	X		X		X	X	X	X		X		X		X	X		X	X
GI CA	Gilia capitata var. abrotinifolia								X										
GI SP	Gilia splendens	X									X								
GN CH	Gnaphalium chilense	X		X		X		X		X	X						X		X
GN PA	Gnaphalium palustre									X									
GU SA	Gutierrezia sarothrae														X				
HA EL	Habenaria elegans		X																
HE KI	Hesperochloa kingii					X											X		
HI AL	Hieracium albiflorum	X								X							X	X	X
HI HO	Hieracium horridum						X												
HO BO	Horkelia bolanderi ssp. parryi	X					X										X		
HU VE	Hulsea vestita				X														
HY FO	Hypericum formosum var. scouleri						X												
IR HA	Iris hartwegii var. australis	X	X	X			X	X	X		X	X				X			X
IV SA	Ivesia santolinoides						X												
JU MA	Juncus macrophyllus						X												
KE GA	Kelloggia galioides									X									
KO CR	Koeleria cristata	X		X	X	X	X	X			X				X		X		
LA LA	Lathyrus laetiflorus		X						X			X				X			
LE VI	Lepidium virginicum var. pubescens					X	X												
LE PU	Leptodactilon pungens				X	X							X						
LI BR	Linanthus breviculus	X			X		X				X	X	X			X			X
LI CI	Linanthus ciliatus	X																X	
LI NU	Linanthus nuttallii							X											
LO AD	Lotus argophyllus var. decorus	X		X			X			X	X			X		X	X	X	X
LO AC	Lotus argyraeus				X						X		X		X				
LO CR	Lotus crassifolius			X			X				X					X			
LO GR	Lotus grandiflorus		X	X															
LO PU	Lotus purshianus							X							X				X
LU AN	Lupinus andersonii	X	X		X					X	X			X		X		X	
LU BR	Lupinus breweri					X					X								X
LU LA	Lupinus latifolius										X								

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able 5. Herbaceous species occurring on the permanent plots (continued)

Species Symbol	Species	Plot																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
LU CO	Luzula comosa									X									
MA CA	Machaeran thera canescens				X	X													
MA EL	Madia elegans ssp. wheeleri	X	X	X							X					X			
ME AR	Melica aristata	X	X	X												X			X
ME ST	Melica stricta																		
MI MO	Mimulus moschatus						X												
MI PI	Mimulus pilosus						X												
MI SU	Mimulus suksdorfii									X									
MO LA	Monardella lanceolata	X						X											
MO LI	Monardella linoides ssp. stricta				X	X	X			X	X	X	X	X	X				
MO PE	Montia perfoliata	X							X									X	X
MU RI	Mohlenbergia rigens						X												
NE SP	Nemophila spatulata		X						X										
NI AT	Nicotiana attenuata														X				
OR HY	Oryzopsis hymenoides				X	X													
OS CH	Osmorhiza chilense	X							X						X			X	
OX PA	Oxytheca parishii															X			
PE SE	Pedicularis semibarbata						X				X		X		X		X	X	X
PE BR	Penstemon bridgesii	X			X						X		X						X
PE CA	Penstemon caesius						X			X									
PE GR	Penstemon grinnellii			X	X	X					X		X						
PE LA	Penstemon labrosus						X	X			X				X				
PH IM	Phacelia imbricata												X	X					
PH MO	Phacelia mohavensis	X					X				X		X						
PH AU	Phlix austromoniana														X				
PH BE	Phoradendron bolleanum var. pauciferum	X												X					
PH FA	Phoradendron flavescens var. villosum		X																
PO FE	Poa fenderliana				X		X	X			X			X	X				X
PO PR	Poa pratensis									X									
PO DO	Polygonum douglasii									X									
PO DJ	Polygonum douglasii var. johnstonii							X											
PO GL	Potentilla glandulosa						X	X	X	X	X					X		X	
PS RI	Psoralea rigida										X				X				
PT AQ	Pteridium aquilinum	X	X	X			X	X	X	X	X					X		X	
PT AN	Pterospora andromedia								X										

Table [illegible] (continued)

-5

Species Symbol	Species	Plot* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
PY PI	Pyrola picta var. aphylla	X												X		X			
SC AU	Scutellaria austinare	X	X				X	X						X		X			
SE IO	Senecio ionophyllus				X														
SI PA	Silene parishii				X	X													
SI VL	Silene verecunda ssp. platyota	X					X			X	X			X	X	X		X	X
SI VP	Silene verecunda spp. platyota va.eglandulosa					X													
SI AL	Sisymbrium altissimum							X											
SI HY	Sitanion hystrix	X		X	X	X	X	X			X	X	X		X		X		X
SO XA	Solanum xantii								X										
SO CA	Solidago californica	X	X	X	X	X	X	X	X		X				X		X	X	
SP CA	Sphenosciadum capitellatum						X												
ST AL	Stachys albens						X												
ST VI	Stephanomaria virgata	X		X															
ST CA	Stipa californica	X		X															
ST CM	Stipa comata				X														
ST CR	Stipa coronata				X														
ST OC	Stipa occidentalis				X	X	X				X		X						
TA PA	Tauschia parishii														X				
TH FE	Thalictrum fendleri															X			
TR MI	Trichostema micranthum														X				
TR MO	Trifolium monathum						X												
TR WO	Trifolium wormskioldii										X								
VE TH	Verbascum thapsus							X											
VE SE	Veronica serpyllifolia						X												
VI CA	Vicia californica	X	X					X	X							X		X	X
ZA CA	Zauscheria californica var. latifolia		X	X			X				X							X	X

* Number	Plot
1	Dogwood
2	Breezy Point
3	Camp Angeles
4	Heart Bar
5	Sand Canyon
6	Snow Valley II
7	Barton Flat
8	N.W. Pavika
9	Bluff Lake
10	Green Valley Creek
11	U.C. Conference
12	N.E. Green Valley
13	Schneider Creek
14	Holcomb Valley
15	Camp O-ongo
16	Camp Oceola
17	Sky Forest
18	Tunnel Two

Appendix I. Sample tree location map: Breezy Point Plot

BREEZY POINT
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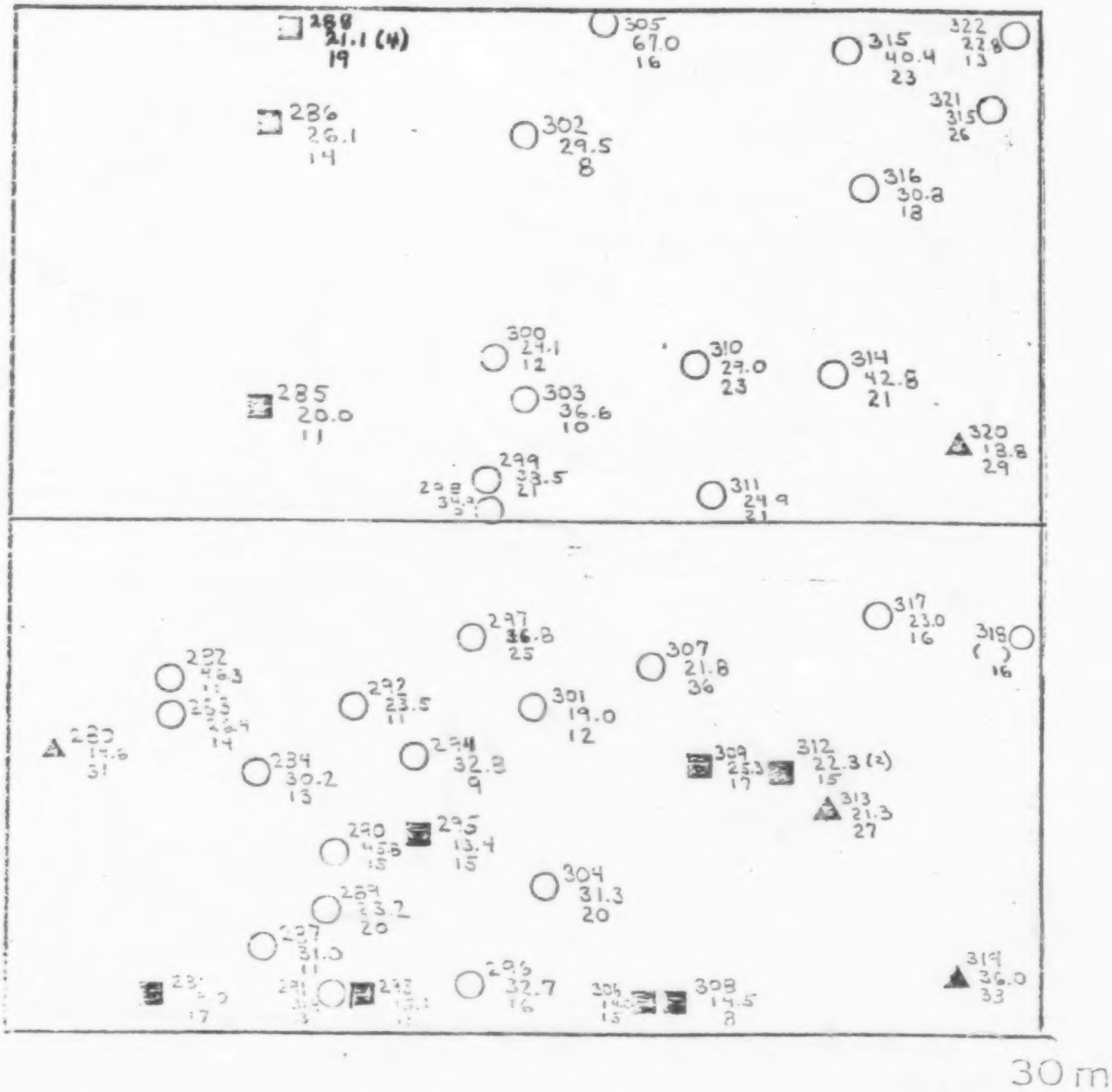
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305
67.0
16
315
40.4
23
322
22.8
13
321
31.5
26
286
26.1
14
302
29.5
8
316
30.8
18
300
29.1
12
310
27.0
23
314
42.8
21
285
20.0
11
303
36.6
10
320
13.8
29
299
33.5
21
298
34.9
311
24.9
21
317
23.0
16
318
( )
16
297
36.8
25
307
21.8
36
282
46.3
11
283
28.4
14
292
23.5
11
301
19.0
12
280
17.6
31
294
32.8
9
284
30.2
13
309
25.3
17
312
22.3 (2)
15
313
21.3
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45.6
15
295
13.4
15
304
31.3
20
289
23.2
20
287
31.0
11
319
36.0
33
296
32.7
16
306
14.8
15
308
14.5
8
281
17
291
3
293
30 m

○ PONDEROSA PINE

■ BLACK OAK

▣ INTERIOR LIVE OAK

▲ INCENSE-CEDAR

○ 123=Tree number
45=DBH (cm.)
29=1973 Smog injury score

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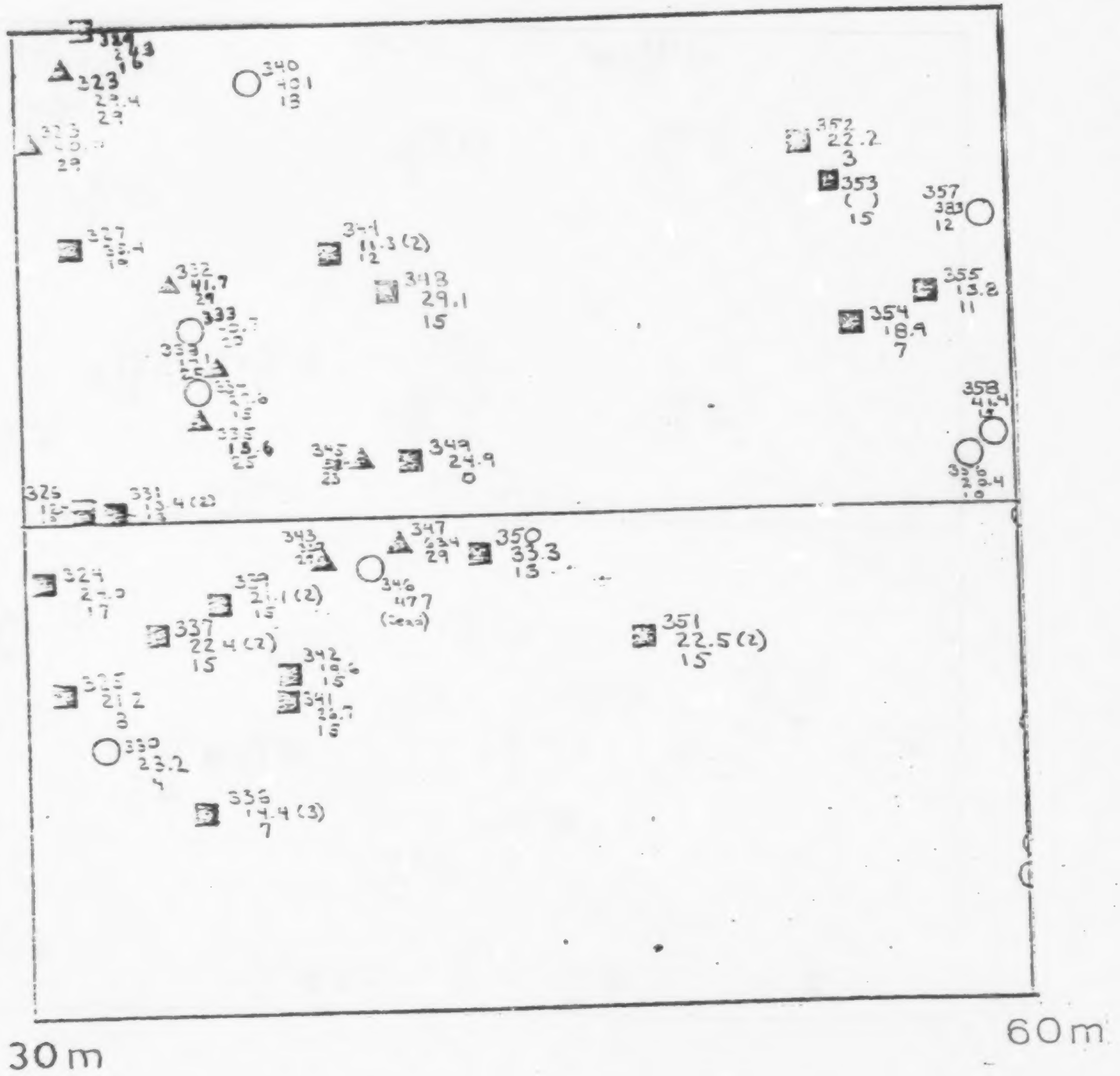
BREEZY POINT
AZIMUTH: 103
LENGTH: 99.6m.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24.3
16
323
29.4
29
340
401
13
327
29
341
11.3 (2)
12
332
41.7
29
348
29.1
15
333
335
15.6
25
345
23
349
24.9
0
326
331
13.4 (2)
13
343
347
234
29
350
33.3
13
346
477
324
17
339
21.1 (2)
15
337
22.4 (2)
15
342
15
341
15
328
21.2
8
330
23.2
4
336
14.4 (3)
7
351
22.5 (2)
15
352
22.2
3
353
( )
15
357
383
12
355
13.2
11
354
18.9
7
358
41.4
22.4
10
30m
60m

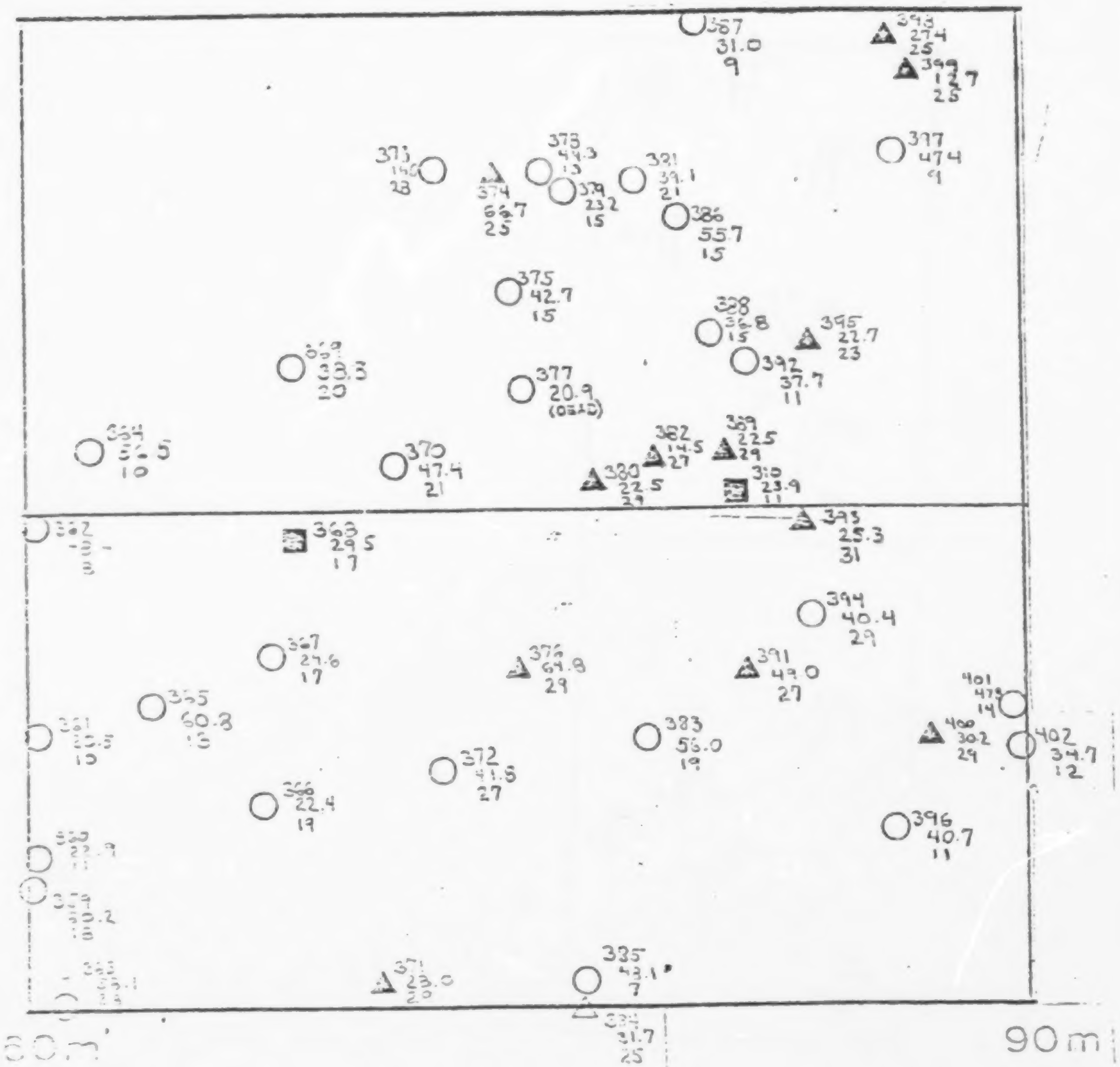
○ PONDEROSA PINE

▨ BLACK OAK

▬ INTERIOR LIVE OAK

△ INCENSE-CEDAR

BREEZY POINT
AZIMUTH: 103
LENGTH: 99.6m.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27.4
25
399
12.7
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397
47.4
9
373
14.6
23
374
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25
378
44.3
13
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23.2
15
381
39.1
21
386
55.7
15
375
42.7
15
388
36.8
15
395
22.7
23
369
38.3
20
377
20.9
(DEAD)
392
37.7
11
364
56.5
10
370
47.4
21
382
14.5
27
389
22.5
29
380
22.5
29
390
23.9
11
368
29.5
17
393
25.3
31
394
40.4
29
367
27.6
17
376
69.8
29
391
49.0
27
401
47.8
14
365
60.8
18
361
20.5
10
383
56.0
19
400
30.2
29
402
34.7
12
372
41.5
27
366
22.4
19
396
40.7
11
360
22.9
11
359
50.2
18
363
35.1
23
371
23.0
20
385
43.1
7
384
31.7
25
80m
90m

○ PONDEROSA PINE

▨ BLACK OAK

≡ INTERIOR LIVE OAK

▲ INCENSE-CEDAR

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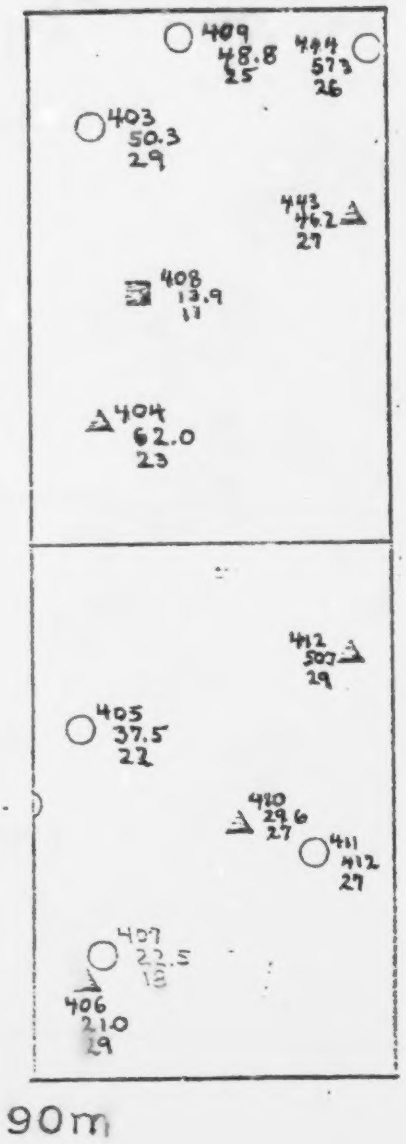
BREEZY POINT
AZIMUTH: 103
LENGTH: 99.6m.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444
57.3
26
403
50.3
29
443
76.2
27
408
13.9
17
404
62.0
23
412
50.7
29
405
37.5
22
410
29.6
27
411
41.2
27
407
22.5
18
406
21.0
29
90m

○ PONDEROSA PINE

▨ BLACK OAK

▤ INTERIOR LIVE OAK

△ INCENSE-CEDAR

III-C

PROGRESS REPORT FY 1974

The role of bark beetles, Dendroctonus spp., in the succession of the mixed conifer ecosystem exposed to photochemical air pollutants.

Principal Investigator: Dr. D. L. Dahlsten

Cooperating Scientists: F. M. Stephen
T. G. Balgooyen
J. K. Wall
M. E. Buegler

Division of Biological Control

Department of Entomological Sciences

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Berkeley, California 94720

OBJECTIVES

Preliminary models (as illustrated in composite Figs. 1, 2, 3; EPA renewal contract 68-03-0273 for FY 1975) showing potential interactions between photochemical air pollutants and the mixed coniferous forest ecosystem, indicate that studies should be directed at primarily 3 levels of organization: organismal, community and stand. The objectives of the bark beetle subproject tie in closely with the objectives outlined in the models. Our objectives are:

(1) To determine the degree of susceptibility of smog damaged ponderosa and jeffrey pine to the western pine beetle (D. brevicomis), the mountain pine beetle (D. ponderosae), and the jeffrey pine beetle (D. jeffreyi).

(2) To investigate the brood productivity of the different bark beetle species in the various classes of smog injured ponderosa and jeffrey pines.

(3) To study the effect of smog on the biology of the three Dendroctonus species and their associates, with particular reference to the parasites and predators.

(4) To develop life tables for and to predict population fluctuations of the three Dendroctonus species in the differing classes of smog injured trees.

The interactive processes at the organismal, community and stand levels, between bark beetle populations, their natural enemies, and varying classes of smog damaged trees, are being elucidated by: (1) intensive within tree sampling of bark beetle populations and their insect associates; (2) field surveys of all established vegetation plots with regard to damage from all

Dendroctonus species; (3) measurement of pertinent physical characteristics of the infested trees, including damage ratings designed to categorize and classify the visible effects of photochemical air pollutants on the tree.

RESULTS

Western pine beetle.--Possession of sophisticated sampling and data management techniques were essential requisites for the satisfaction of the group's objectives. Sampling techniques have been developed for the western pine beetle from an extensive population study at the University of California's Blodgett Experimental Research Forest and these techniques are applicable to the current project.

It is believed that the western pine beetle undergoes two generations each year in the San Bernardino mountain area. One generation involves flight of the adult beetles to find and mass attack new host trees; gallery construction and egg deposition by the attacking adults; larval development and subsequent emergence of the new brood. Beetles which are partially developed prior to the onset of winter, complete their development and emerge the following spring.

It was critical for accurate population estimates to find newly attacked trees before brood development had proceeded too far. Personnel from the California State Division of Forestry and the U. S. Forest Service were instrumental in finding the areas with currently active bark beetle populations, which was very helpful, as such searches were extremely time consuming.

To facilitate proper statistical evaluation of the population data we utilized 12 study trees during each of the two beetle generations. To obtain the necessary population data, four distinct sampling routines were followed for each of the 24 study trees in 1973: 1) egg disc analysis, 2) x-ray analysis, 3) rearing analysis, and 4) sticky carton analysis. Included in Appendix 1 are the raw data recording sheets from one of the study trees, number 17.

The basic tree statistics as formatted in $TREE (Appendix 1) include: plot number, tree number, sample year, sample day, beetle generation, total tree height, top of infestation, circumference at top of infestation, base of infestation, circumference at base of infestation, and the amount of bark removed by woodpeckers at each sampling interval. Phloem thickness and phloem moisture estimates were not taken previously, but will be measured for all future sample trees.

All insects which were found with the sample unit at the time of sampling are identified were recorded on $TBUG (Appendix 1).

The sample unit was 88 square centimeters for all four types of sampling. The samples in all cases were taken from the base of the tree to the top of the western pine beetle infested bole.

The egg samples ($EGGS: Appendix 1) were taken only once, usually two to three weeks after attack. Two 88 cm^2 discs were taken at 3.0 meter intervals over the length of the infested bole. The discs were dissected, and the total number of eggs, 1st instar larvae, gallery length, and number of attacks were recorded.

At the same time that the egg discs were taken the first x-ray and rearing discs were taken. The sample consisted of two 88 cm^2 discs at 1.5 meter intervals along the length of the infested bole. Each disc was x-rayed and then placed in a laboratory rearing carton so that two types of information were obtained from each sample. These samples were taken once during the first generation in 1973, as these trees were discovered late in the beetle's developmental stages and early x-ray samples could not be obtained. The 12 trees in generation two were sampled three times.

The pair of discs from each height were x-rayed on the same sheet of film. The film was developed and then interpreted ($XRAY: Appendix 1). The stage of the western pine beetle was determined and then parasites, predators, and miscellaneous insects were identified generally, as they can not be determined specifically on the film. The percentage of woodpeckering on each disc was determined prior to x-raying.

After x-raying each disc was placed in a rearing carton. The cartons were checked three times a week for insects. The insects that were collected were curated and identified ($REAR: Appendix 1). After 9 to 12 months the samples will be terminated and the attacks and gallery length recorded.

Cartons which cover an area of 88 cm^2 were placed on the tree at 1.5 m intervals over the length of the infested bole at the time of the second or last x-ray/rear sampling. The cartons are referred to as sticky cartons as STIKEM SPECIAL was smeared on a portion of the inside of the carton to keep insects from boring out. The cartons were left up on the trees until sometime after western pine beetle brood emergence. The cartons were taken down when the first larval (i.e., x-ray/rear) samples were taken for the following generation. The same kind of information was recorded for the sticky cartons ($STIK: Appendix 1) as for those samples that were reared in the laboratory. The rationale for using sticky cartons as well as rearing x-ray samples was due to the different rearing conditions and the possible effects on the many different species collected.

The first generation sampling was relatively straightforward but generation two was complicated by the onset of winter. Samples were taken in August and late September, but the last samples were not taken until the following spring prior to final brood emergence. Sticky cartons were placed on the trees in late September and removed in late October, for the purpose of determining if any pre-winter emergence occurred. An extra set of x-ray/rear samples and sticky emergence cartons were taken for this particular generation in early April 1974. This was done to monitor beetle population emergence with extra care during the initial sampling year. The totals of all samples taken are listed in Table I.

The extent of woodpecker activity on the infested bark surface was measured on all sample trees, and preliminary population censuses were made in April and May of 1974 to estimate their densities in the study areas.

All 24 sample trees were checked to determine the extent of oxidant damage, using the rating system of Miller.[1] The scores from these smog ratings are listed (Table II).

ANALYSIS

All population data from the 24 trees sampled in F.Y. 1974 have been recorded on the appropriate forms. These forms have been submitted for key-punching and subsequent entry into the data banking system described in the

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[1] Miller, P. R. 1973. Oxidant damage to conifers. In Oxidant air pollutant effects on a western coniferous forest ecosystem. Task C report. EPA Grant No. 68-02-0303.

EPA renewal, contract 68-03-0273 for FY 1975. Summarization and analysis of the bark beetle population data will then be accomplished. Summarization of population raw data was not feasible without the completed computer programs, as approximately 2000 pages of population data have thus far been collected.

The raw data sheets from one tree, #17 (Appendix 1) contain: $TREE and $TBUG sheets from sample Julian dates 234 (22 August 1973), 262 (19 September 1973), and 91 (1 April 1974); $EGGS sheet from 234 (22 August); $XRAY from 234, 262 and 91; $STIK sheets from 262 (cartons removed 298 (25 October));and one $REAR sheet from each of the 3 sample dates (there are 87 more pages of $REAR data from this tree that weren't included in this appendix). The keys to the insect code names and valid insect entries are listed in Appendix 7, EPA renewal, contract 68-03-0273 for FY 1975.

INSECT DAMAGE SURVEY

In order to monitor the more apparent insect activity throughout all study areas, surveys of insect damage with particular emphasis on bark beetle activity, were conducted on all established vegetation plots in the fall of 1973. The vegetation group has categorized all trees on the plots as to species and measured pertinent characteristics including the smog rating. Trees found infested during the insect surveys had information taken as to tree number and species, insect species present, stage of bark beetle brood, and probable time of attack and emergence. These data are valuable not only for determining susceptibility of smog damaged trees to bark beetles, but also yield important information on the biology of the different species. This may include number of insect generations per year, overlap in timing of generations, frequency of mixed brood (i.e., 2 bark beetle species) within the trees, and length of generation times.

Table I. Total number of samples taken--fiscal year 1974.

Generation 1 1973:

- 12 trees (no.'s 1-12) sampled once 17-20 July, 1973.
  - 258 x-ray samples
  - 128 egg samples
  - 196 sticky emergence carton samples [removed 17-20 September, 1973]
  - 582 total samples

Generation 2 1973:

- 12 trees (no.'s 13-24) sampled three times.
  - 1st sampling (21-23 August, 1973)
    - 204 x-ray samples
    - 102 egg samples
  - 2nd sampling (17-19 September, 1973)
    - 22[illegible] x-ray samples
    - 222 sticky emergence carton samples [removed 23-25 October, 1973]
    - 8 egg samples
  - 3rd sampling (1-4 April, 1974)
    - 194 x-ray samples
    - 194 sticky emergence carton samples
  - 1150 total samples

Table II. Smog Rating--1973 *D. brevicomis* sample trees.

Tree #	Needle Retention		Needle Condition*		Needle Length	Branch Mortality	Total: Without Needle Condition	Total
	Upper	Lower	Upper	Lower				
1	3	3	4,4,2	4,2,2	1	1	8	26
2	3	3	4,4,2	4,2,2	1	1	8	26
3	3	3	4,4,2	4,2,2	1	1	8	26
4	4	3	4,4,2,2	4,2,2	1	1	9	29
5	4	4	4 4,2,2	4,4,2,2	1	1	10	31
6	3	3	4,4,2	4,4,2	1	1	8	28
7	2	2	4,2	4,2	1	1	6	18
8	4	3	4,4,4,2	4,4,2	1	1	9	33
9	5	5	4,4,4,4,2	4,4,4,2,2	1	0	11	45
10	3	3	4,4,2	4,2,2	0	1	7	25
11	3	3	4,4,2	4,2,2	0	1	7	25
12	2	2	4,2	4,2	1	1	6	18
13	2	2	4,2	4,2	0	1	5	17
14	2	2	2,2	2,2	0	0	4	12
15	2	2	4,2	2,2	1	1	6	16
16	2	2	4,2	2,2	0	1	5	15
17	1	1	2	2	1	1	4	8
18	4	4	4,4,4,2	4,4,4,2	1	1	10	38
19	4	4	4,4,4,2	4,4,4,2	1	1	10	38
20	2	2	4,2	2,2	0	0	4	14
21	2	2	4,2	2,2	0	0	4	14
22	2	1	2,0	2	0	0	3	7
23	1	1	2	2	0	0	2	6
24	2	2	4,2	4,2	1	1	6	18

*Needle condition not able to be accurately evaluated as many of the trees had already begun to fade and thus chlorotic coloration not detectable and subjectively determined.

SAMPLING TEAM Ohmart - Stephen
PLOT LOCATION Camp Angelus

SAMPLE USE:

NOTES: Tree just fading to a straw color. (Was not faded this much when found last Thurs.) very poor needle retention - just current yrs.

DATA TYPE [1].*TREE
FORMAT [2].4
CONTINUATION NUMBER [3].1
GEOGRAPHIC AREA [4].SB
PLOT NUMBER [5].
TREE NUMBER [6].17
SAMPLE YEAR [7].73
SAMPLE JULIAN DAY [8].234
GENERATION [9].732
TOTAL TREE HEIGHT [10].275
TOP OF INFESTATION [11].227
CIRC. AT TOP INFEST. [12].81
BASE OF INFESTATION [13].2
CIRC. AT BASE INFEST. [14].190
CIRC. AT BREAST HT. [15].176
ENG(E) OR METRIC(M) [16].M

	1 DISK #	2 USE	3 WOODPECK. BAND (CIRC.)	4 DIRC.	5 HEIGHT	6 CIRC.	7 PHLOEM THICK.	8 BARK THICK.	9 WOODPECK 90 DISK
[17]	1	2	0	N	225	84		5-10	
[18]	2	1		N					
[19]	1	2		S				1-11	
[20]	2	1		S	↓	↓			
[21]	1	1		N	210	95		5-11	
[22]	1	1		S	↓	↓		5-12	
[23]	1	2		N	195	107		5-10	
[24]	2	1		N					
[25]	1	2		S				6-12	
[26]	2	1		S	↓	↓			
[27]	1	1		N	180	118		5-12	
[28]	1	1		S	↓	↓		2-15	
[29]	1	2		N	165	122		2-12	
[30]	2	1		N					
[31]	1	2		S				6-12	
[32]	2	1		S	↓	↓			
[33]	1	1		N	150	131		5-12	
[34]	1	1		S	↓	↓		5-[illegible]	
[35]	1	2		N	135	137		6-12	
[36]	2	1	↓	N	↓	↓			

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Appendix 1 (cont.)

SAMPLING TEAM ______________

PLOT LOCATION ______________

SAMPLE USE:

NOTES:

DATA TYPE [1]. S.T.R.E.E. 4.

FORMAT [2]. . . . . . .

CONTINUATION NUMBER [3] 2. . . . . .

GEOGRAPHIC AREA [4]. S.B. . . . . .

PLOT NUMBER [5]. . . . . . .

TREE NUMBER [6]. 1 7. . . . . .

SAMPLE YEAR [7]. 7 3. . . . .

SAMPLE JULIAN DAY [8]. 2 3 4. . . . .

GENERATION [9]. 7. 3. 2. . . . .

TOTAL TREE HEIGHT [10]. . . . . . .

TOP OF INFESTATION [11]. . . . . . .

CIRC. AT TOP INFEST. [12]. . . . . . .

BASE OF INFESTATION [13]. . . . . . .

CIRC. AT BASE INFEST. [14]. . . . . . .

CIRC. AT BREAST HT. [15]. . . . . . .

ENG(E) OR METRIC(M) [16]. M. . . . . .

	1 DISK #	2 USE	3 WOODPECK. BAND (CIRC.)	4 DIRC.	5 HEIGHT	6 CIRC.	7 PHLOEM THICK.	8 BARK THICK.	9 WOODPECK 90 DISK
[17]	1	2	0	S	135	137		8-12	
[18]	2	1	↓	S	↓	↓			
[19]	1	1	↓	N	120	140		5-12	
[20]	1	1	↓	S	↓	↓		5-15	
[21]	1	2	↓	N	105	146		6-12	
[22]	2	1	↓	N	↓	↓			
[23]	1	2	↓	S	↓	↓		6-12	
[24]	2	1	↓	S	↓	↓			
[25]	1	1	↓	N	90	148		6-12 D. ponderosae galleries	
[26]	1	1	↓	S	↓	↓		6-13	
[27]	1	2	↓	N	75	150		5-12	
[28]	2	1	↓	N	↓	↓			
[29]	1	2	↓	S	↓	↓		7-13	
[30]	2	1	↓	S	↓	↓			
[31]	1	1	↓	N	60	153		4-14	
[32]	1	1	↓	S	↓	↓		7-15	
[33]	1	2	↓	N	45	156		10-17 Clerids +	
[34]	2	1	↓	N	↓			Medetera on	
[35]	1	2	↓	S	↓			6-18 bark surface	
[36]	2	1	↓	S	↓	↓			

Appendix 1 (cont.)

SAMPLING CREW ____________________
PLOT LOCATION ____________________

SAMPLE USE:

NOTES:

DATA TYPE [1]. S.T.R.E.E.
FORMAT [2]. 4
CONTINUATION NUMBER [3]. 3
GEOGRAPHIC AREA [4]. S.B.
PLOT NUMBER [5].
TREE NUMBER [6]. 1 7
SAMPLE YEAR [7]. 7
SAMPLE JULIAN DAY [8].
GENERATION [9].
TOTAL TREE HEIGHT [10].
TOP OF INFESTATION [11].
CIRC. AT TOP INFEST. [12].
BASE OF INFESTATION [13].
CIRC. AT BASE INFEST. [14].
CIRC. AT BREAST HT. [15]. 1 7 6
ENG(E) OR METRIC(M) [16].

	1	2	3	4	5	6	7	8	9
	DISK #	USE	WOODPECK. BAND (CIRC.)	DIRC.	HEIGHT	CIRC.	PHLOEM THICK.	BARK THICK.	WOODPECK % DISK
[17]	1	1	0	N	30	162		6-22	
[18]	1	1	↓	S	↓	↓		10-18	
[19]	1	2		N	15	176		7-30	
[20]	2	1		N	↓	↓			
[21]	1	2		S				7-26	
[22]	2	1	↓	S	↓	↓			
[23]									
[24]									
[25]									
[26]									
[27]									
[28]									
[29]									
[30]									
[31]									
[32]									
[33]									
[34]									
[35]									

```
DATA_TYPE     FORMAT          CONT._NUMBER
GEOG_AREA     PLOT            TREE_NUMBER
SAMPLE_YR     SAMPLE_J_DAY    GENERATION

[1]  $TGUG  2         1
[2]  SB              17
[3]  73    234      732
[4]
[5]  *225  N
[6]  DENB  AU         1
[7]
[8]  *210  N
[9]  BUPR  IU         1
[10]
[11] *195  S
[12] DENB  AU         1
[13] CECI  IU         2
[14]
[15] *150  N
[16] AULL  AU         1
[17]
[18] *150  S
[19] AULL  AU         1
[20]
[21] *135  N
[22] CORP  AU         3
[23]
[24] *135  S
[25] BUPR  IU         1
[26]
[27] *120  S
[28] BUPR  IU         2
[29]
[30] *105  N
[31] BUPR  IU         1
[32]
[33] *105  S
[34] DENB  AU         1
[35]
[36] *75   N
[37] DENB  AU         2
[38]
[39] *75   S
[40] BUPR  IU         1
[41] DENB  AU         1
[42]
[43] *60   N
[44] BUPR  IU         1
[45]
[46] *60   S
[47] DENB  AU         1 Dead
[48]
[49] *45   N
[50] DENB  AU         1
[51]
[52] *45   S
[53] DENB  AU         2
[54]
[55] *30   S
[56] DENB  AU         2
[57]

[58] *15   N
[59] DENB  AU         4 alive
[60] DENB  AU         1 dead
[61] MEDA  IU         1
[62]
[63] *15   S
[64] DENB  AU         3 alive
[65]
[66]
[67]
[68]
[69]
[70]
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[72]
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[74]
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[76]
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[105]
[106]
[107]
[108]
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Appendix 1 (cont.)

SAMPLING CREW [illegible] + Wall
PLOT LOCATION [illegible]

SAMPLE USE:

NOTES:

1st page of 3

DATA TYPE [1]. S.T.R.E.E.
FORMAT [2]. 4
CONTINUATION NUMBER [3].
GEOGRAPHIC AREA [4]. S.B.
PLOT NUMBER [5].
TREE NUMBER [6]. 17
SAMPLE YEAR [7]. 73
SAMPLE JULIAN DAY [8]. 262
GENERATION [9]. 2
TOTAL TREE HEIGHT [10].
TOP OF INFESTATION [11].
CIRC. AT TOP INFEST. [12].
BASE OF INFESTATION [13].
CIRC. AT BASE INFEST. [14].
CIRC. AT BREAST HT. [15].
ENG(E) OR METRIC(M) [16]. M

	1 DISK #	2 USE	3 WOODPECK. BAND (CIRC.)	4 DIRC.	5 HEIGHT	6 CIRC.	7 PHLOEM THICK.	8 BARK THICK.	9 WOODPECK % DISK
[17]	2	3	3	N	210			1-16	
[18]	2	3	↓	S	↓			4-13	10
[19]	3	4	↓	N	↓				
[20]	3	4	↓	S	↓				
[21]	3	3	6	N	195			3-12	
[22]	3	3	↓	S	↓			3-11	
[23]	4	4	↓	N	↓				
[24]	4	4	↓	S	↓				
[25]	2	3	5	N	180			1-12	
[26]	2	3	↓	S	↓			5-12	
[27]	3	4	↓	N	↓				
[28]	3	4	↓	S	↓				
[29]	3	3	5	N	165			3-12	20
[30]	3	3	↓	S	↓			5-11	
[31]	4	4	↓	N	↓				
[32]	[illegible]	4	↓	S	↓				
[33]	2	3	3	N	150			2-12	
[34]	[illegible]	[illegible]	↓	S	↓			5-13	
	[illegible]	[illegible]	↓	N	↓				

Appendix 1 (cont.)

SAMPLING TEAM ________________
PLOT LOCATION ________________
--- ________________________

SAMPLE USE:

NOTES:

2nd page of 3

DATA TYPE [1]. S T R E E . 4
FORMAT [2]. . . . . . 4.
CONTINUATION NUMBER [3] 2
GEOGRAPHIC AREA [4] S.B.
PLOT NUMBER [5].
TREE NUMBER [6] 17
SAMPLE YEAR [7] 73
SAMPLE JULIAN DAY [8] 262
GENERATION [9] 2
TOTAL TREE HEIGHT [10].
TOP OF INFESTATION [11].
CIRC. AT TOP INFEST. [12].
BASE OF INFESTATION [13].
CIRC. AT BASE INFEST. [14].
CIRC. AT BREAST HT. [15].
ENG(E) OR METRIC(M) [16] M

	1 DISK #	2 USE	3 WOODPECK. BAND (CIRC.)	4 DIRC.	5 HEIGHT	6 CIRC.	7 PHLOEM THICK.	8 BARK THICK.	9 WOODPECK % DISK
[17]	3	3	12	N	135			1-14	
[18]	3	3	↓	S	↓			4-13	
[19]	4	4	↓	N	↓				
[20]	4	4	↓	S	↓				
[21]	2	3	8	N	120			4-13	5
[22]	2	3	↓	S	↓			4-13	
[23]	3	4	↓	N	↓				
[24]	3	4	↓	S	↓				
[25]	3	3	15	N	105			4-10	
[26]	3	3	↓	S	↓			3-13	
[27]	4	4	↓	N	↓				
[28]	4	4	↓	S	↓				
[29]	2	3	5	N	90			1-12	
[30]	2	3	↓	S	↓			5-20	
[31]	3	4	↓	N	↓				
[32]	3	4	↓	S	↓				
[33]	2	3	15	N	75			2-15	5
[34]	2	3	↓	S	↓			4-13	
[35]	4	4	↓	N	↓				
[36]	4	4	↓	S	↓				

Appendix 1 (cont.)

SAMPLING TEAM ________________

PLOT LOCATION ________________

____

SAMPLE USE:

NOTES:

3rd page of 3

DATA TYPE	[1]	$TREE
FORMAT	[2]	4
CONTINUATION NUMBER	[3]	3
GEOGRAPHIC AREA	[4]	SB
PLOT NUMBER	[5]	
TREE NUMBER	[6]	17
SAMPLE YEAR	[7]	73
SAMPLE JULIAN DAY	[8]	262
GENERATION	[9]	2
TOTAL TREE HEIGHT	[10]	
TOP OF INFESTATION	[11]	
CIRC. AT TOP INFEST.	[12]	
BASE OF INFESTATION	[13]	
CIRC. AT BASE INFEST.	[14]	
CIRC. AT BREAST HT.	[15]	
ENG(E) OR METRIC(M)	[16]	M

	1 DISK #	2 USE	3 WOODPECK. BAND (CIRC.)	4 DIRC.	5 HEIGHT	6 CIRC.	7 PHLOEM THICK.	8 BARK THICK	9 WOODPECK % PICK
[17]	2	3	12	N	60			4-14	
[18]	2	3	↓	S	↓			4-13	
[19]	3	4	↓	N	↓				
[20]	3	4	↓	S	↓				
[21]	3	3	3	N	45			3-18	
[22]	3	3	↓	S	↓			4-17	
[23]	4	4	↓	N	↓				
[24]	4	4	↓	S	↓				
[25]	2	3	3	N	30			5-18	
[26]	2	3	↓	S	↓			6-18	
[27]	3	4	↓	N	↓				
[28]	3	4	↓	S	↓				
[29]	3	3	0	N	15			6-31	
[30]	3	3	↓	S	↓			5-25	
[31]	4	4	↓	N	↓				
[32]	4	4	↓	S	↓				
[33]	3	3	10	N	225			3-10	
[34]	3	3	↓	S	↓			2-11	
[35]	4	4	↓	N	↓				
	4	4		S	↓				

[illegible] [illegible] CARD_NUMBER
[illegible] PLOT TREE_NUMBER
SAMPLE_YR SAMPLE_J_DAY GENERATION

[1]	STBUG	2		
[2]	SB		17	
[3]	73	262	2	
[4]				
[5]	*225	N		
[6]	DENB	AU	1	PA alive
[7]	*210	S		
[8]	CORP		1	
[9]	*210	N		
[10]	CERM	IU	1	
[11]	MEDA	IU	1	
[12]	*195	S		
[13]	CERM	IU	1	
[14]	MEDA	IU	1	
[15]	*195	N		
[16]	CERM	IU	1	
[17]	*165	S		
[18]	CERM	IU	1	
[19]	*150	S		
[20]	CERM	IU	1	
[21]	*150	N		
[22]	CERM	IU	1	
[23]	CORP	AU	3	
[24]	ENDC	IU	1	
[25]	*135	N		
[26]	CERM	IU	1	
[27]	*120	S		
[28]	DENB	AU	1	dead
[29]	*105	N		
[30]	AULL	AU	1	
[31]	CORP	AU	1	
[32]	ENDC	AU	1	
[33]	*90	S		
[34]	CERM	IU	1	
[35]	[illegible]	IU	1	
[36]	*90	N		
[37]	DENB	AU	1	dead
[38]	*75	S		
[39]	NULC		1	
[40]	*75	N		
[41]	AULL		1	
[42]	PLEN		1	
[43]	NULC		1	
[44]	DENB	AU	1	PA alive
[45]	*60	N		
[46]	AULL		1	
[47]	CERM	IU	1	
[48]	CORP		1	
[49]	*45	N		
[50]	[illegible]	[illegible]	1	
[51]	AULL		1	
[52]	*[illegible]			
[53]	[illegible]	[illegible]		
[54]				
[55]	[illegible]		1	
[56]	*[illegible]	[illegible]		
[57]	ALE[illegible]		1	
[58]	*15	S		
[59]	CERM	IU	1	
[60]	XYLE		1	
[61]				
[62]				
[63]				
[64]				
[65]				
[66]				
[67]				
[68]				
[69]				
[70]				
[71]				
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[103]				
[104]				
[105]				
[106]				
[107]				
[108]				

Appendix 1 (cont.)

SAMPLING CREW Wenz & Stephen

PLOT LOCATION Camp Angelus

SAMPLE USE:

NOTES: No Emergence
Trace of woodpeckering

Emergence at 150

First of three sheets

X-rayed 95-74

DATA TYPE [1]. S.T.R.E.E.
FORMAT [2]. 4
CONTINUATION NUMBER [3]. 1
GEOGRAPHIC AREA [4]. S.B.
PLOT NUMBER [5].
TREE NUMBER [6]. 17
SAMPLE YEAR [7]. 74
SAMPLE JULIAN DAY [8]. 91
GENERATION [9]. 732
TOTAL TREE HEIGHT [10].
TOP OF INFESTATION [11].
CIRC. AT TOP INFEST. [12].
BASE OF INFESTATION [13].
CIRC. AT BASE INFEST. [14].
CIRC. AT BREAST HT. [15].
ENG(E) OR METRIC(M) [16].

	1	2	3	4	5	6	7	8	9
	DISK #	USE	WOODPECK. BAND (CIRC.)	DIRC.	HEIGHT	CIRC.	PHLOEM THICK.	BARK THICK.	WOODPECK % DISK
[17]	5	4	0	N	225				
[18]	5	4	↓	S	↓				
[19]	6	3	↓	N	↓			4-9	
[20]	6	3	↓	S	↓			5-9	
[21]	5	4	3	N	210				
[22]	5	4	↓	S	↓				
[23]	4	3	↓	N	↓			3-9	15
[24]	4	3	↓	S	↓			4-8	15
[25]	5	4	3	N	195				
[26]	5	4	↓	S	↓				
[27]	6	3	↓	N	↓			5-9	
[28]	6	3	↓	S	↓			6-10	
[29]	5	4	3	N	180				
[30]	5	4	↓	S	↓				
[31]	4	3	↓	N	↓			5-11	2
[32]	4	3	↓	S	↓			7-10	
[33]	5	4	5	N	165				
[34]	5	4	↓	S	↓				
[35]	6	3	↓	N	↓			7-11	5
	6	3	↓	S	↓			7-10	10

Appendix 1 (cont.)

SAMPLING TEAM WENZ + Stephen
PLOT LOCATION CAMP ANGELES

SAMPLE USE:

NOTES:

2nd of three sheets

DATA TYPE [1] S.T.R.E.E.
FORMAT [2] 4
CONTINUATION NUMBER [3] 2
GEOGRAPHIC AREA [4] S.B.
PLOT NUMBER [5]
TREE NUMBER [6] 1 7
SAMPLE YEAR [7] 7 4
SAMPLE JULIAN DAY [8] 9 1
GENERATION [9] 7 3 2
TOTAL TREE HEIGHT [10]
TOP OF INFESTATION [11]
CIRC. AT TOP INFEST. [12]
BASE OF INFESTATION [13]
CIRC. AT BASE INFEST. [14]
CIRC. AT BREAST HT. [15]
ENG(E) OR METRIC(M) [16]

	1	2	3	4	5	6	7	8	9
	DISK #	USE	WOODPECK BAND (CIRC.)	DIRC.	HEIGHT	CIRC.	PHLOEM THICK.	BARK THICK.	WOODPECK % DISK
[17]	5	4	3	N	150				
[18]	5	4	↓	S	↓				
[19]	4	3		N				9-10	2
[20]	4	3		S				7-10	2
[21]	5	4	5	N	135				
[22]	5	4	↓	S	↓				
[23]	6	3		N				8-11	5
[24]	6	3		S				5-10	
[25]	5	4	10	N	120				
[26]	5	4	↓	S	↓				
[27]	4	3		N				7-11	5
[28]	4	3		S				7-11	10
[29]	5	4	0	N	105				
[30]	5	4	↓	S	↓				
[31]	6	3		N				6-10	20
[32]	6	3		S				7-10	5
[33]	5	4	0	N	90				
[34]	5	4	↓	S	↓				
[35]	4	3		N				9-13	1
[36]	4	3		S				7-12	5

SAMPLING TEAM ________________

PLOT LOCATION ________________

SAMPLE USE:

NOTES:

3rd of three sheets

DATA TYPE [1]. S T R E E

FORMAT [2]. . . . . . 4.

CONTINUATION NUMBER [3]. . . . . . 3.

GEOGRAPHIC AREA [4]. S B . . . .

PLOT NUMBER [5]. . . . . . .

TREE NUMBER [6]. 1 7 . . . . .

SAMPLE YEAR [7]. 7 4 . . . . .

SAMPLE JULIAN DAY [8]. 9 1 . . . . .

GENERATION [9]. 7 3 2 . . . .

TOTAL TREE HEIGHT [10]. . . . . . .

TOP OF INFESTATION [11]. . . . . . .

CIRC. AT TOP INFEST. [12]. . . . . . .

BASE OF INFESTATION [13]. . . . . . .

CIRC. AT BASE INFEST. [14]. . . . . . .

CIRC. AT BREAST HT. [15]. . . . . . .

ENG(E) OR METRIC(M) [16]. . . . . . .

	1 DISK #	2 USE	3 WOODPECK. BAND (CIRC.)	4 DIRC.	5 HEIGHT	6 CIRC.	7 PHLOEM THICK.	8 BARK THICK.	9 WOODPECK % DISK
[17]	5	4	10	N	75				
[18]	5	4	↓	S	↓				
[19]	6	3	↓	N	↓			9-12	1.5
[20]	6	3	↓	S	↓			6-8	2
[21]	5	4	5	N	60				
[22]	5	4	↓	S	↓				
[23]	4	3	↓	N	↓			8-14	
[24]	4	3	↓	S	↓			6-10	10
[25]	5	4	0	N	45				
[26]	5	4	↓	S	↓				
[27]	6	3	↓	N	↓			11-16	5
[28]	6	3	↓	S	↓			1-13	
[29]	5	4	2	N	30				
[30]	5	4	↓	S	↓				
[31]	4	3	↓	N	↓			10-20	
[32]	4	3	↓	S	↓			10-20	5
[33]	5	4	0	N	1.5				
[34]	5	4	↓	S	↓				
[35]	6	3	↓	N	↓			25-27	
	6	3	↓	S				16-20	

```
DATA_TYPE.    [illegible]    CONT_NUMBER      [1]. STBUG  2        1
C_W_AREA      PLOT           SLIDE_NUMBER     [2]. SB             17
SAMPLE_ID     SAMPLE_J_DAY   GENERATION       [3]. 74     91     732
                                              [4].
                                              [5].  *165            N
                                              [6]. CUCU  IU         2
[59].                                         [7].  *150            N
[60].                                         [8]. COLE  IU         2
[61].                                         [9].  *150            N
[62].                                         [10]. CUCU  IU        1
[63].                                         [11].  *105           S
[64].                                         [12]. PLEN            2
[65].                                         [13].  *105           S
[66].                                         [14]. CORP            3
[67].                                         [15].  *90            N
[68].                                         [16]. CUCU  IU        1
[69].                                         [17].  *75            N
[70].                                         [18]. CERM  IU        1
[71].                                         [19].  *45            6
[72].                                         [20]. PLEN            1
[73].                                         [21].  *45            S
[74].                                         [22]. LONC  IU        1
[75].                                         [23].  *45            N
[76].                                         [24]. CUCU  IU        2
[77].                                         [25].  *45            N
[78].                                         [26]. CORP            1
[79].                                         [27].  *45            N
[80].                                         [28]. LONC  IU        1
[81].                                         [29].  *30            N
[82].                                         [30]. CUCU  IU        3
[83].                                         [31].  *30            N
[84].                                         [32]. AULL            1
[85].                                         [33].  *30            S
[86].                                         [34]. CUCU  IU        1
[87].                                         [35].  *15            N
[88].                                         [36]. CUCU  IU        1
[89].                                         [37].  *15            N
[90].                                         [38]. LONC  IU        1
[91].                                         [39].
[92].                                         [40].
[93].                                         [41].
[94].                                         [42].
[95].                                         [43].
[96].                                         [44].
[97].                                         [45].
[98].                                         [46].
[99].                                         [47].
[100].                                        [48].
[101].                                        [49].
[102].                                        [50].
[103].                                        [51].
[104].                                        [52].
                                              [53].
                                              [54].
                                              [55].
                                              [56].
                                              [57].
```

Appendix 1
(cont.)

DATA_TYPE FORMAT CONT._NUMBER [1].$EGGS. 1. . . . 2
GEOG_AREA PLOT_NUMBER TREE_NUMBER [2] SB. . . . 7
SAMPLE_YR SAMPLE_J_DAY GENERATION [3].73. . 234 .73.2

	T	RISK #	HEIGHT	DIRECTION	BALL LENGTH	# ATTACKS	# DEAD EGGS	# 1ST LARVAE	
[4]		1	15	N	46	2	17	26	
[5]		1	15	S	36	3	15	27	
[6]		1	45	N	26	1	5	21	
[7]		1	45	S	44	2	12	24	
[8]		1	105	N	52	1	7	41	
[9]		1	105	S	46	1	15	33	
[10]		1	135	N	32	1	9	36	
[11]		1	135	S	33	1	5	37	
[12]		1	165	N	31	0	13	26	
[13]		1	165	S	27	0	6	14	
[14]		1	195	N	21	0	13	28	
[15]		1	195	S	13	0	1	14	
[16]		1	225	N	17	0	7	19	
[17]		1	255	S	0	0	0	0	
[18]		1	75	N	45	2	16	20	
[19]		1	75	S	30	0	9	20	
[20]									
[21]									
[22]									
[23]									
[24]									
[25]									
[26]									
[27]									
[28]									

Appendix 1 (cont.)

TB-MA-JW

DATA_TYPE FORMAT CONT._NUMBER
GEOG_AREA PLOT_NUMBER TREE_NUMBER
SAMPLE_YR SAMPLE_J_DAY GENERATION
DATE_DOWN

[1]	XRAY	2	1
[2]	SB		17
[3]	73	234	732
[4]			
[5]	*1	15	N
[6]	*1	15	S
[7]	LAL		9
[8]	MIS		1
[9]	*1	30	N
[10]	LAL		12
[11]	MIS		2
[12]	*1	30	S
[13]	LAL		5
[14]	*1	45	N
[15]	LAL		16
[16]	PAR		1
[17]	*1	45	S
[18]	LAL		8
[19]	MIS		1
[20]	*1	60	N
[21]	LAL		2
[22]	*1	60	S
[23]	PUL		3
[24]	LAL		11
[25]	*1	75	N
[26]	LAL		4
[27]	*1	75	S
[28]	PUL		1
[29]	LAL		12
[30]	*1	90	N
[31]	LAL		6
[32]	PRE		1
[33]	*1	90	S
[34]	LAL		8
[35]	*1	105	N
[36]	PAD		1
[37]	LAL		2
[38]	*1	105	S
[39]	LAL		7
[40]	MIS		1
[41]	*1	120	N
[42]	LAL		2
[43]	*1	120	S
[44]	LAL		6
[45]	*1	135	N
[46]	PUL		2
[47]	LAL		9
[48]	*1	135	S
[49]	LAL		5
[50]	*1	150	N
[51]	LAL		12
[52]	*1	150	S
[53]	LAL		13
[54]	PRE		2
[55]	*1	165	N
[56]	LAL		2
[57]	PRE		3
[58]	*1	165	S
[59]	LAL		11
[60]	*1	180	N
[61]	PUL		2
[62]	LAL		21
[63]	*1	180	S
[64]	LAL		8
[65]	PRE		1
[66]	*1	195	N
[67]	LAL		10
[68]	*1	195	S
[69]	LAL		1
[70]	PAR		1
[71]	*1	210	N
[72]	LAL		3
[73]	*1	210	S
[74]	*1	225	N
[75]	PUL		1
[76]	*1	225	S
[77]	LAL		2
[78]	MIS		1
[79]			
[80]			
[81]			
[82]			
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[85]			
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[104]			
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[106]			
[107]			
[108]			

Appendix 1 (cont.)

TB-JW-MR

DATA_TYPE	FORMAT	CONT._NUMBER
GEOG_AREA	PLOT_NUMBER	TREE_NUMBER
SAMPLE_YR	SAMPLE_J DAY	GENERATION
DATE_DOWN		

[1]	DX.RAY	2	1
[2]	S.B		17
[3]	73	262	732
[4]			
[5]	*3	15	N
[6]	*3	15	S
[7]	LAL		3
[8]	*2	30	N
[9]	PUL		2
[10]	LAL		1
[11]	PRE		1
[12]	*2	30	S
[13]	LAL		3
[14]	*3	45	N
[15]	PAL		1
[16]	PUL		1
[17]	LAL		5
[18]	*3	45	S
[19]	PAL		1
[20]	PUL		1
[21]	*2	60	N
[22]	PUL		2
[23]	LAL		4
[24]	*2	60	S
[25]	PAL		1
[26]	LAL		2
[27]	*3	75	N
[28]	PAL		2
[29]	PUL		2
[30]	PAR		1
[31]	PRE		1
[32]	*3	75	S
[33]	PUL		1
[34]	LAL		1
[35]	PRE		1
[36]	*2	90	N
[37]	PAL		2
[38]	PUL		4
[39]	*2	90	S
[40]	PAR		1
[41]	*3	105	N
[42]	PUL		1
[43]	LAL		5
[44]	*3	105	S
[45]	PAL		1
[46]	PUL		2
[47]	PRE		3
[48]	*2	120	N
[49]	PAL		1
[50]	MIS		1
[51]	*2	120	S
[52]	PAL		5
[53]	PUL		1
[54]	*3	135	N
[55]	LAL		6
[56]	PRE		1
[57]	MIS		3
[58]	*3	135	S
[59]	PAL		3
[60]	PUL		2
[61]	PRE		1
[62]	MIS		2
[63]	*2	150	N
[64]	PAL		2
[65]	PUL		3
[66]	MIS		1
[67]	*2	150	S
[68]	MIS		2
[69]	*3	165	N
[70]	PAL		1
[71]	PUL		1
[72]	LAL		1
[73]	LAD		1
[74]	MIS		3
[75]	*3	165	S
[76]	PUL		1
[77]	MIS		3
[78]	*2	180	N
[79]	PUL		2
[80]	LAL		1
[81]	PRE		1
[82]	*2	180	S
[83]	PUL		1
[84]	PUD		1
[85]	LAL		1
[86]	*3	195	N
[87]	PAL		1
[88]	PRE		1
[89]	MIS		2
[90]	*3	195	S
[91]	PAL		1
[92]	PUL		1
[93]	PUD		2
[94]	LAL		1
[95]	*2	210	N
[96]	PAL		4
[97]	PAD		1
[98]	PUL		4
[99]	LAL		1
[100]	PRE		1
[101]	*2	210	S
[102]	PRE		2
[103]	MIS		1
[104]	*3	225	N
[105]	/		/
[106]	*3	225	S
[107]	/		/
[108]			

Sample [illegible]

Appendix 1 (cont.)

DATA_TYPE FORMAT CONT._NUMBER
GEOG_AREA PLOT_NUMBER TREE_NUMBER
SAMPLE_YR SAMPLE_J_DAY GENERATION
DATE_DOWN

[1]. X.RAY 2 1
[2]. S.B 17
[3]. 74 91 732
[4].
[5]. *6 15 N
[6]. *6 15 S
[7]. LAL 1
[8]. *4 30 N
[9]. LAL 1
[10]. *4 30 S
[11]. PRE 1
[12]. *6 45 N
[13]. PAR 1
[14]. *6 45 S
[15]. PRE 1
[16]. *4 60 N
[17]. *4 60 S
[18]. PRE 1
[19]. *6 75 N
[20]. *6 75 S
[21]. PAR 1
[22]. PRE 1
[23]. MIS 1
[24]. *4 90 N
[25]. PRE 1
[26]. *4 90 S
[27]. LAD 1
[28]. PUL 1
[29]. PRE 1
[30]. *6 105 N
[31]. LAL 1
[32]. PRE 1
[33]. MIS 1
[34]. *6 105 S
[35]. PUL 1
[36]. LAL 1
[37]. PRE 1
[38]. *4 120 N
[39]. PRE 2
[40]. *4 120 S
[41]. *6 135 N
[42]. PRE 1
[43]. *6 135 S
[44]. PRE 2
[45]. MIS 2
[46]. *4 150 N
[47]. *4 150 S
[48]. PUL 1
[49]. PAR 1
[50]. PRE 1
[51]. MIS 1
[52]. *6 165 N
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[54]. PRE 1
[55]. *4 180 N
[56]. PUL 3
[57]. PRE 2
[58]. *4 180 S
[59]. *6 195 N
[60]. PUL 1
[61]. PRE 2
[62]. *6 195 S
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[64]. PRE 2
[65]. *4 210 N
[66]. *4 210 S
[67]. PRE 1
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[69]. *6 225 N
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[106].
[107].
[108].

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DATA_TYPE    FORMAT           CONT._NUMBER
GEOG_AREA    PLOT_NUMBER      TREE_NUMBER
SAMPLE_YR    SAMPLE_J_DAY     GENERATION
DATE_DOWN

[1]  93TIK   2         1
[2]  9B               17
[3]  73     262      732
[4]  73298
[5]
[6]    *4    15        N
[7]  DENB    AF        1
[8]  LEPT              1
[9]  GRET              2
[10] AULL              1
[11]   *4    15        S
[12] LYCD              2
[13] PITY              1
[14] SCIA              1
[15]   *3    30        N
[16] BRAC              1
[17] AULL              1
[18] SCIA              1
[19] PLEN              1
[20] CORP              1
[21]   *3    30        S
[22] DENB    AM        1
[23] PHOR              1
[24] CORP              2
[25] SCIA              4
[26]   *4    45        N
[27] DENB    AM        2
[28] DENB    AF        2
[29] ELEC    IU        1
[30] AULL              1
[31]   *4    45        S
[32] CORP              8
[33] COLE    IU        1
[34] NUDC              1
[35] SCIA              1
[36] LYCD              1
[37]   *3    60        N
[38] DENB    AM        3
[39] DENB    AF        3
[40]   *3    60        S
[41] COLE    IU        2
[42] DENB    AF        1
[43]   *4    75        N
[44] AULL              2
[45] PLEN              1
[46] LASS              1
[47]   *4    75        S
[48] DENB    AM        1
[49] DENB    AF        3
[50]   *3    90        N
[51] DENB    AF        5
[52] DENB    AM        2
[53] SCIA              1
[54] AULL              1
[55]   *3    90        S
[56] CORP              1
[57] ELEC    IU        1
[58] EMPT              1
[59] NUDC              3
[60]   *4   105        N
[61] DENB    AM        4
[62] DENB    AF        2
[63] NUDC              1
[64]   *4   105        S
[65] RAPH    IU        1
[66] COLE    IU        1
[67] CORT              1
[68] CORP              1
[69]   *3   120        N
[70] AULL              1
[71] SCIA              1
[72]   *3   120        S
[73] DENB    AM        2
[74] DENB    AF        3
[75] CORP              2
[76]   *4   135        N
[77] DENB    AM        1
[78] DENB    AF        3
[79]   *4   135        S
[80] DENB    AM        3
[81] DENB    AF        2
[82] PLEN              2
[83] CORP              2
[84]   *3   150        N
[85] DENB    AM        2
[86] DENB    AF        3
[87]   *3   150        S
[88] DENB    AM        1
[89] AULL              1
[90]   *4   165        N
[91] DENB    AM        1
[92] CORP              1
[93]   *4   165        S
[94] AULL              1
[95] CECI              1
[96]   *3   180        N
[97] DENB    AM        2
[98] DENB    AF        2
[99]   *3   180        S
[100] DENB   AM        1
[101] DENB   AF        1
[102]  *4   195        N
[103] DENB   AM        2
[104] CORP             2
[105] AULL             1
[106] CECI             1
[107] ELEC   IU        1
[108] SCIA             2
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Appendix 1 (cont.)

DATA_TYPE FORMAT CONT._NUMBER
GEOG_AREA PLOT_NUMBER TREE_NUMBER
SAMPLE_YR SAMPLE_J_DAY GENERATION
DATE_DOWN

[1] Q.S.T.I.K. 2 . . . 2
[2] S.B. 17
[3] 73 . . 262 . 732
[4] 73298
[5]
[6] . *4 . 195 . . . S
[7] DENB . An 1
[8] . *3 . 210 . . . N
[9] DENB . Am . . . 1
[10] NUDC 1
[11] NUDC . IU . . . 1
[12] CORP 1
[13] . *3 . 210 . . . S
[14] . *4 . 225 . . . N
[15] ALEQ 1
[16] LASS 1
[17] CORT 3
[18] . *4 . 225 . . . S
[19] DENB AM 1
[20] DENB AF 1
[21] CORT 1
[22] ELEC 1
[23] LASS 1
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[106]
[107]
[108]

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DATA_TYPE     FORMAT        CONT._NUMBER   (1).$ R E A R . 1 . . . . 1.
GEOG_AREA   PLOT_NUMBER   TREE_NUMBER      (2) S.B. . . . . . . . . 17.
SAMPLE_YR  SAMPLE_J_DAY   GENERATION       (3).73. . .234. . .732.
DISK_NUMBER      HEIGHT     DIRECTION      (4). . . . 60. . . . . 5.
THICK_MIN    THICK_MAX    WOODPECK_D       (5).7. . . .15. . . . . 0.
GALLERY_LENGTH              NO._ATTACKS    (6). . . . . . . . . . . . .

( 58). . . . . . . . . . . . . .    (  7). . *COLL . . . 274.
( 59). . . . . . . . . . . . . .    (  8).D.E.N.B. .AM. . . . 1.
( 60). . . . . . . . . . . . . .    (  9).D.E.N.B. .PF. . . . 2.
( 61). . . . . . . . . . . . . .    ( 10). *C.O.LL . . .303.
( 62). . . . . . . . . . . . . .    ( 11).DENB. .AM . . . . 2.
( 63). . . . . . . . . . . . . .    ( 12).DENB. .A.F. . . . 2.
( 64). . . . . . . . . . . . . .    ( 13) D.E.N.B. AU. . . . 1.
( 65). . . . . . . . . . . . . .    ( 14). . . . . . . . . . . . .
( 66). . . . . . . . . . . . . .    ( 15). . . . . . . . . . . . .
( 67). . . . . . . . . . . . . .    ( 16). . . . . . . . . . . . .
( 68). . . . . . . . . . . . . .    ( 17). . . . . . . . . . . . .
( 69). . . . . . . . . . . . . .    ( 18). . . . . . . . . . . . .
( 70). . . . . . . . . . . . . .    ( 19). . . . . . . . . . . . .
( 71). . . . . . . . . . . . . .    ( 20). . . . . . . . . . . . .
( 72). . . . . . . . . . . . . .    ( 21). . . . . . . . . . . . .
( 73). . . . . . . . . . . . . .    ( 22). . . . . . . . . . . . .
( 74). . . . . . . . . . . . . .    ( 23). . . . . . . . . . . . .
( 75). . . . . . . . . . . . . .    ( 24). . . . . . . . . . . . .
( 76). . . . . . . . . . . . . .    ( 25). . . . . . . . . . . . .
( 77). . . . . . . . . . . . . .    ( 26). . . . . . . . . . . . .
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( 79). . . . . . . . . . . . . .    ( 28). . . . . . . . . . . . .
( 80). . . . . . . . . . . . . .    ( 29). . . . . . . . . . . . .
( 81). . . . . . . . . . . . . .    ( 30). . . . . . . . . . . . .
( 82). . . . . . . . . . . . . .    ( 31). . . . . . . . . . . . .
( 83). . . . . . . . . . . . . .    ( 32). . . . . . . . . . . . .
( 84). . . . . . . . . . . . . .    ( 33). . . . . . . . . . . . .
( 85). . . . . . . . . . . . . .    ( 34). . . . . . . . . . . . .
( 86). . . . . . . . . . . . . .    ( 35). . . . . . . . . . . . .
( 87). . . . . . . . . . . . . .    ( 36). . . . . . . . . . . . .
( 88). . . . . . . . . . . . . .    ( 37). . . . . . . . . . . . .
( 89). . . . . . . . . . . . . .    ( 38). . . . . . . . . . . . .
( 90). . . . . . . . . . . . . .    ( 39). . . . . . . . . . . . .
( 91). . . . . . . . . . . . . .    ( 40). . . . . . . . . . . . .
( 92). . . . . . . . . . . . . .    ( 41). . . . . . . . . . . . .
( 93). . . . . . . . . . . . . .    ( 42). . . . . . . . . . . . .
( 94). . . . . . . . . . . . . .    ( 43). . . . . . . . . . . . .
( 95). . . . . . . . . . . . . .    ( 44). . . . . . . . . . . . .
( 96). . . . . . . . . . . . . .    ( 45). . . . . . . . . . . . .
( 97). . . . . . . . . . . . . .    ( 46). . . . . . . . . . . . .
( 98). . . . . . . . . . . . . .    ( 47). . . . . . . . . . . . .
( 99). . . . . . . . . . . . . .    ( 48). . . . . . . . . . . . .
(100). . . . . . . . . . . . . .    ( 49). . . . . . . . . . . . .
(101). . . . . . . . . . . . . .    ( 50). . . . . . . . . . . . .
(102). . . . . . . . . . . . . .    ( 51). . . . . . . . . . . . .
(103). . . . . . . . . . . . . .    ( 52). . . . . . . . . . . . .
(104). . . . . . . . . . . . . .    ( 53). . . . . . . . . . . . .
(105). . . . . . . . . . . . . .    ( 54). . . . . . . . . . . . .
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(108). . . . . . . . . . . . . .    ( 57). . . . . . . . . . . . .
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DATA_TYPE      [illegible]      COUNT_NUMBER     (1).$.R.E.A.R. .1. . . . . . .1.
[illegible]    PLOT_NUMBER      TREE_NUMBER      (2).S.B. . . . . . . . . . .17.
SAMPLE_YR      SAMPLE_J_DAY     ELEVATION        (3).7.3. . .2.6.2. . . .7.3.2
DISK_NUMBER    HEIGHT           DIRECTION        (4).3. . . . . .4.5. . . . .N.
THICK_[illegible]  THICK_[illegible]  [illegible]  (5).3. . . . . .1.8. . . . .0.
GALLERY_LENGTH                  NO._ATTACKS      (6). . . . . . . . . . . . . .

 ( 58). . . . . . . . . . . . . . .      (  7). .*.COLL. . . .277.
 ( 59). . . . . . . . . . . . . . .      (  8).P.L.E.N. . . . . . .1.
 ( 60). . . . . . . . . . . . . . .      (  9).D.E.N.B. .AF. . . . . .
 ( 61). . . . . . . . . . . . . . .      ( 10). .*.COLL. . . .288.
 ( 62). . . . . . . . . . . . . . .      ( 11).DEN.B. .AM. . . . .2.
 ( 63). . . . . . . . . . . . . . .      ( 12).D.ENB. .AF. . . . .1.
 ( 64). . . . . . . . . . . . . . .      ( 13). .*.C.O.LL. . . .303.
 ( 65). . . . . . . . . . . . . . .      ( 14).C.E.R.A. . . . . . . .1.
 ( 66). . . . . . . . . . . . . . .      ( 15). . . . . . . . . . . . . .
 ( 67). . . . . . . . . . . . . . .      ( 16). . . . . . . . . . . . . .
 ( 68). . . . . . . . . . . . . . .      ( 17). . . . . . . . . . . . . .
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 ( 75). . . . . . . . . . . . . . .      ( 24). . . . . . . . . . . . . .
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 ( 77). . . . . . . . . . . . . . .      ( 26). . . . . . . . . . . . . .
 ( 78). . . . . . . . . . . . . . .      ( 27). . . . . . . . . . . . . .
 ( 79). . . . . . . . . . . . . . .      ( 28). . . . . . . . . . . . . .
 ( 80). . . . . . . . . . . . . . .      ( 29). . . . . . . . . . . . . .
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 ( 82). . . . . . . . . . . . . . .      ( 31). . . . . . . . . . . . . .
 ( 83). . . . . . . . . . . . . . .      ( 32). . . . . . . . . . . . . .
 ( 84). . . . . . . . . . . . . . .      ( 33). . . . . . . . . . . . . .
 ( 85). . . . . . . . . . . . . . .      ( 34). . . . . . . . . . . . . .
 ( 86). . . . . . . . . . . . . . .      ( 35). . . . . . . . . . . . . .
 ( 87). . . . . . . . . . . . . . .      ( 36). . . . . . . . . . . . . .
 ( 88). . . . . . . . . . . . . . .      ( 37). . . . . . . . . . . . . .
 ( 89). . . . . . . . . . . . . . .      ( 38). . . . . . . . . . . . . .
 ( 90). . . . . . . . . . . . . . .      ( 39). . . . . . . . . . . . . .
 ( 91). . . . . . . . . . . . . . .      ( 40). . . . . . . . . . . . . .
 ( 92). . . . . . . . . . . . . . .      ( 41). . . . . . . . . . . . . .
 ( 93). . . . . . . . . . . . . . .      ( 42). . . . . . . . . . . . . .
 ( 94). . . . . . . . . . . . . . .      ( 43). . . . . . . . . . . . . .
 ( 95). . . . . . . . . . . . . . .      ( 44). . . . . . . . . . . . . .
 ( 96). . . . . . . . . . . . . . .      ( 45). . . . . . . . . . . . . .
 ( 97). . . . . . . . . . . . . . .      ( 46). . . . . . . . . . . . . .
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 (101). . . . . . . . . . . . . . .      ( 50). . . . . . . . . . . . . .
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 (104). . . . . . . . . . . . . . .      ( 53). . . . . . . . . . . . . .
 (105). . . . . . . . . . . . . . .      ( 54). . . . . . . . . . . . . .
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 (108). . . . . . . . . . . . . . .      ( 57). . . . . . . . . . . . . .
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Appendix 1 (cont.)

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DATA_TYPE      FORMAT          COUNT_NUMBER     (1). $ R E A R  1              1
STUDY_AREA     PLOT_NUMBER     TREE_NUMBER      (2). S.B                      17
SAMPLE_YR      SAMPLE_J_DAY    GENERATION       (3). 74        92            732
DISK_NUMBER    HEIGHT          DIRECTION        (4). 5         135             S
THICK_1        THICK_2         [illegible]      (5). 5         10              0
GALLERY_LENGTH                 NO._ATTACKS      (6).

( 58).                                          ( 7). X.COLL                 116
( 59).                                          ( 8). METE                     2
( 60).                                          ( 9).
( 61).                                          (10).
( 62).                                          (11).
( 63).                                          (12).
( 64).                                          (13).
( 65).                                          (14).
( 66).                                          (15).
( 67).                                          (16).
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(102).                                          (51).
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(107).                                          (56).
(108).                                          (57).
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III-D

Effects of Photochemical Air Pollutants on Microbial Activity Associated with Litter Decomposition and Nutrient Cycling

Principal Investigator, Dr. J. R. Parmeter
Co-Investigator, Dr. F. Cobb

Department of Plant Pathology
University of California
Berkeley, California 94720

Effects of Photochemical Air Pollution on Microbial Activity Associated With Litter Decomposition and Nutrient Cycling

Progress with this project has been in three major directions. A healthy start has been made towards collecting and isolating fungi associated with different stages of litter decomposition and nutrient cycling. A laboratory method of determining relative rates of needle litter decomposition is being tested. Also, soil populations of fungi are being estimated and described in conjunction with ongoing soil microarthropod studies.

During the fall of 1973, senescing needles were collected from trees exhibiting varying states of health on sites of heavy, medium, light, and "no" air pollution. Heavily and lightly damaged trees, relative to each of these sites,were selected and collections were made of needles shed during 1973 and others which had spent a winter on the ground. A similar collection was made in the early spring of 1974. Preliminary isolations suggest that there are relatively few organisms which colonize otherwise healthy, senescent ponderosa and Jeffrey pine needles on the tree. It also appears that a small number of organisms are involved in initial decomposition during the first winter on the ground. As isolations continue to be made and are identified, the patterns of microbial succession in needle decomposition will be clarified. These organisms will then be tested further to determine both the ability of these fungi to function in an ecosystem modified by photochemical air pollution (stand-level interactions) and the impact of these pollutants on the organisms themselves (organism-level interactions). Two combination fumigation growth chambers are being remodelled to permit laboratory as well as field testing of these relationships.

The pilot needle decomposition study involves the exposure of needles to an inoculum (ground duff is presently being used) on an initially sterile, periodically moistened paper towel in a large test tube. If successful, this method could become standard for testing laboratory decomposition of various needle substrates by appropriate inocula under diverse environmental conditions.

Soil samples contiguous to those taken for the forest floor microarthropod project have been and will continue to be taken. Soil fungus population estimates are made from these samples, and progress is being made in the description of the forest floor microflora.

All data for this project are being collected on plots monitored for soil temperature, moisture, etc. This will allow further correlation with other projects in the study.

III-E

Effects of Photochemical Air Pollution on the Epidemiology of Root Pathogens in the Mixed-Conifer Forest

Principal Investigator, Dr. F. Cobb
Co-Investigator, Dr. J. R. Parmeter

Effects of Photochemical Air Pollution on the Epidemiology of Root Pathogens in the Mixed-Conifer Forest

Progress with this project has been made in two major directions. Field studies on the epidemiology of *Fomes annosus* are well under way, and laboratory studies have been planned. The damping-off complex is being studied both by bioassay with seedlings in the greenhouse and by direct soil assay in the laboratory. Field experiments dealing with this complex of organisms are also planned.

Isolates of *Fomes annosus* have been obtained from a number of plot sites within the overall study area, through the use of sterile pine disc spore traps. These isolates have been cultured and are being used as native inoculum sources in inoculation studies. Live ponderosa and Jeffrey pines near plot sites varying in exposure to air pollution have been inoculated with *Fomes annosus*, using the local isolates mentioned above. Isolated trees near each plot were selected, to minimize the threat of spread, and exhibited varying degrees of the visible symptoms of air pollution damage. Remodelling of two large growth chambers, to permit fumigation work, is nearly completed. Studies involving the fumigation of pure fungal cultures, seedlings inoculated with *Fomes annosus*, and uninoculated seedlings are planned.

A preliminary damping-off experiment using spinach and radish seeds (no pine seeds were available), grown in duffs and soils from a number of plot sites, was carried out in the greenhouse. Percent damping-off was low for all plots. Fungi isolated from apparently damped-off seedlings are being maintained in culture for reference and pathogenicity tests. Laboratory procedures used successfully for the estimation of populations of *Rhizoctonia*, *Pythium*, and *Thielaviopsis* in agricultural soils are being applied to soils and duffs collected from the plot sites. No *Rhizoctonia* was found in soils collected from ten trees on five plots in March, 1974. The assay for *Pythium* from these soils is still incomplete, but none has been found to date. The assays for *Thielaviopsis* from soil, and all three organisms from duff, will follow immediately. Field experiments on damping-off of pine seedlings are planned for this coming field season.

All data for this project are being collected on plots monitored for soil temperature, moisture, etc. This will allow further correlation with other projects in the study.

III-F

Effects of Photochemical Air Pollutants
on Litter Accumulation and Soil Properties

Principal Investigator, Dr. W. W. Wilcox
Co-Investigator, Nancy D. Oldham

Forest Products Laboratory
Richmond Field Station
University of California
Berkeley, California 94720

Introduction

Oxidant injury to ponderosa and jeffrey pines has probably increased the amount of litter on the forest floor. The rate of decay of this litter affects soil properties and soil nutrients levels, which in turn affects the flora and fauna of the soil. Seed germination, seedling survival and stand condition are all directly affected by the litter decay rate. In this study, sites and trees were selected to coordinate with and extent the studies of the subgroups concerned with soil properties, root pathogens, needle decomposition, nutrient cycling and soil micro-arthropods. (See Figure 1.)

Objectives

A major factor in assessing the effect of air pollutants on litter accumulation and soil properties is the effect upon the rate of decomposition of plant material falling to the forest floor. To investigate this effect the objectives, for the first year of this study, were as follows: 1. To choose sites coordinated with the other subprojects, 2. To isolate wood decay fungi from the larger pieces of litter accumulated on these sites, 3. To compile a collection of the predominant microorganisms, 4. To select and identify from the collection, the major wood decaying fungi, 5. To have built to our specifications a gas exposure chamber in which to test the effects of ozone on the growth rate and decay rate of the isolated decay fungi as compared to several common wood decay fungi never before exposed to air pollutants, and 6. To collect sound wood specimens from areas of various levels of long-term air pollution damage for next year's analysis of the decay resistance of these specimens.

Research Progress

The study was begun with the inspection of twelve possible sites. Their smog rating, vegetation, precipitation, and litter depth were noted. Nine sites were selected having low, medium and high oxidant damage scores with a high score indicating the least or no damage (See Table 1.) Samples were collected four times during the year. (All nine sites were not always accessable). Samples consisted of litter 1.5 cm or larger in diameter.

Isolations were made from these samples of wood by aseptically removing a small sliver of wood from an aseptically opened section of the sample. These slivers were placed on malt agar, water agar and a medium selective for some common Basidiomycetes. From these isolations, a stock collection of the predominant fungi present is being assembled. Microscopical examination of the hyphae of these fungi for clamp connections has resulted in seven Basidiomycetes with the testing of the collection not yet completed. The possibility exists that some of these Basidiomycetes are duplicates; this will be investigated when the isolations are completed. Isolation from the last collection (April 26, 1974) is still in progress.

The ability of 15 fungi from the collection to decay ponderosa wood blocks was investigated. Sterile wood blocks were placed on actively growing cultures of the fungi and incubated for six weeks. Weight loss (evidence of decay) was insignificant when compared to a laboratory stock culture of _Poria monticola_ Murr., used as a control test organism, and uninoculated blocks. This was a preliminary screening test of decay ability and will serve as a guide line in further growth and decay rate studies.

Specifications for a gas exposure chamber were selected. Ten major suppliers of controlled environment chambers were requested to bid on these specifications. From the replies one supplier was chosen and we are currently awaiting permission from EPA to negotiate a contract. Final selection of ozone generation equipment, mode of detection, etc. will be completed after the contract for the chamber is obtained.

Sound ponderosa wood specimens (free from decay and insects) were collected with the cooperation of the Forest Service from an area rated 15 and an area rated 25. The 15-rated area has a history of smog dating from 1950. There was no possible site with a better (higher, therefore less pollution) rating than 25 that would have ponderosa pine trees rather than jeffrey. Two trees form each site were sampled, one with very severe damage and one with very slight or no visible damage. The wood will be tested for any changes in its resistance to decay.

Relation to Overall Project

The forest's microbial population is the primary element in the process of litter decomposition and nutrient recycling. Any variation in the number of decay fungus species involved in litter decomposition or in the decay rate of these fungi affects the nature of the litter substrate, and hence the entire forest ecosystem. As the species and abundance of micro-organisms may be affected by air pollutants, it is important to establish the changes that this modification imposes on litter accumulation and the forest ecosystem as a whole.

Isolations of wood-decaying fungi are being made from sites coordinated with those of the entire soils subproject. These sites are in turn related to the air-pollution monotoring subproject as all litter samples are collected from smog rated trees evaluated for air pollution damage and climatic conditions.

Any alteration by air pollutants of the growth rate and activity of wood-decaying organisms could alter a number of concerns of the soils subproject and the project as a whole, among them: litter production, litter depth, soil texture, soil moisture holding capacity, soil nutrient level, occurrence of mycorrhiza and root pathogens, microarthropod food supply, seed germination, seedling survival and overall stand condition.

Figure 1. Organism Level Interactions

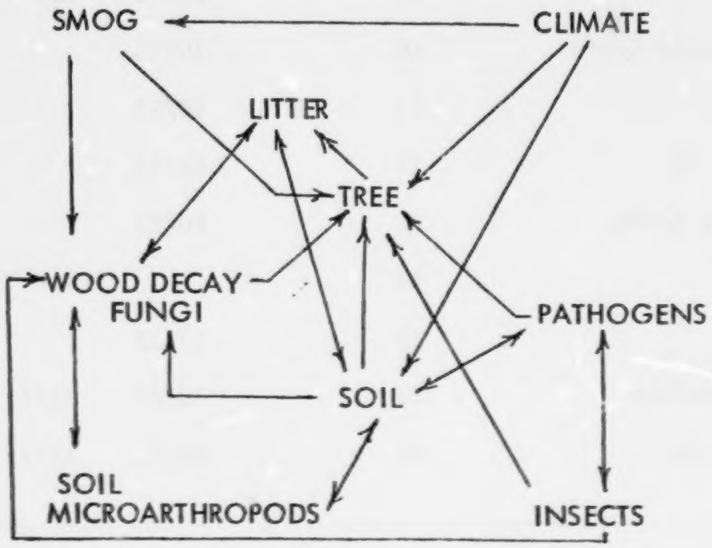
SMOG
CLIMATE
LITTER
TREE
WOOD DECAY FUNGI
PATHOGENS
SOIL
SOIL MICROARTHROPODS
INSECTS

Table I. Investigated Sites

Site	Oxidant Damage Score (Oct.73)	Dates of Collection			
Sky Forest	13	10/73	12/73	3/74	4/74
Camp O-ongo	16	10/73	12/73	3/74	4/74
U.C. Conference Center	16	10/73	-	3/74	4/74
Dogwood	17	10/73	-	3/74	*
Snow Valley II	21	10/73	-	3/74	4/74
Green Valley Creek	21	10/73	-	-	-
Tunnel Two+	25	-	-	-	4/74
Bluff Lake	29	10/73	-	-	4/74
N.E. Green Valley	33	10/73	12/73	-	4/74
Holcomb Valley	46	10/73	12/73	3/74	4/74

*Discontinued
+Add April, 1974

Summary

An investigation of the effect of air pollutants on litter accumulation and the rate of decomposition of larger pieces of litter by the major decay fungi was begun. The first year's objectives of isolation of fungi, establishment of a culture collection, identification from the collection of major decay fungi, the establishment of a basis for future testing of decay resistance and coordination with the other subprojects have been accomplished or initiated.

III-G

Annual Report FY 74

Renewal EPA Contract 68-03-0273

EFFECTS OF OXIDANT AIR POLLUTANTS ON FOREST FLOOR MICROARTHROPODS

Principle Investigator

J. M. Wenz

Cooperating Investigators

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Introduction

In any interdisciplinary ecosystem study, close interaction among the component research projects is imperative. As described in Section II of the FY 1974 Protocol, Renewal,EPA contract 68-03-0273, the three proposed general models and the various submodels represent these interactions and the relationship of each part to the whole. In part these models describe the forest floor microarthropod section of the study and its relationship to the other research projects,principally Air Pollution and Meteorological Monitoring, Effects on Successional Pattern, Litter Decomposition and Nutrient Cycling, and Soil Properties, Litter, and Soil-Plant-Climate Interactions. (Fig. II-1, 1A, 2, 2A, 3, II-1,2,3 and Table II-1, 1A, 2, 2A, 3). These relationships are evident in the objectives listed below and are discussed in more detail in Section III-G of the Protocol FY 1974.

Objectives

1. To determine species composition, relative abundance, seasonal population fluctuations, and vertical and horizontal distribution patterns between oxidant weakened and healthy trees and between areas of high, medium, and low air pollutant concentrations.

2. To correlate species composition and population density with specific biotic and abiotic forest floor and mineral soil properties.

3. To identify, as far as possible, specific components of the soil microarthropod community as indicators and monitors of an ecosystem disrupted by oxidant air pollution.

4. To determine and compare characteristics of ecological disruptions of soil microarthropods caused by oxidant air pollutants with undisturbed

(natural) sites and with disruptions caused by other factors i.e., pesticides, fire, logging . . . .

5. To develop and evaluate sampling techniques to measure and describe soil microarthropod population.

Research Progress--FY 1974

I. Establishment of study trees.

Two individual study trees have been established in each of the following plots:

Plot	Plot Oxidant Level (1973)	Tree No. and oxidant rating(1973)
Breezy Point	Moderate (16)	394 (29) 397 (9)
Snow Valley II	Moderate (21)	753 (14) 785 (12)
N. E. Green Valley	Very-slight (33)	614 (24) 618 (26)

The Snow Valley II and N. E. Green Valley study trees were established in August 1973 as were trees in Dogwood and Barton Flats. The latter two were discontinued in the interests of coordination with other research groups and the Breezy Point trees were established in November 1973. The tree species involved are Jeffrey pine (Snow Valley II and N. E. Green Valley) and ponderosa pine (Breezy Point). The plots were chosen in an attempt to get a comparison between areas of different oxidant level concentrations ranging from high-moderate (16) at Breezy Point to very-slight (33) at N. E. Green Valley. In addition, the individual trees chosen exhibit a range of oxidant damage from heavy (9) to relatively unaffected (29). An attempt,largely unsuccessful, was made to choose undisturbed trees isolated and relatively uninfluenced from adjacent trees to minimize possible sources of variability.

In addition, an effort was made to work with trees, at least within plot, that were of similar size and age class.

II. Sampling

Samples are taken at six week intervals, with some variations due to snow and weather conditions. To date a total of 814 sub-cores have been taken on the following dates: 1973--August 16-17, October 3-4, November 28-29 and 1974--April 2-3 and May 20-21. With the exception of the May 20-21 sample, all samples have been extracted and counting analysis completed. Each sample is approximately 30 sq. cm. in area and taken to a depth of 5 cm in the mineral soil. Where appropriate, the different forest floor and mineral soil layers (litter, fermentation, humus, 0-5 cm mineral soil) are measured (cm) and stored separately for individual extraction. The forest floor beneath each sample tree is divided up into eight quadrats using the cardinal directions, the exact dimensions of which are dependent on crown size, ground cover and other forest floor disturbances. Samples are taken by randomly selecting the quadrat and direction from the tree bole. Each individual core (10 per tree/sample date) is mapped as precisely as possible using the quadrat angle (from N, 0-360°) and the distance from the bole. (This is coordinated directly with the Litter Decomposition and Nutrient Cycling project which samples at the same time and same location.)

III. Extraction

All cores taken in the field are kept at cool temperatures in specially constructed ice chests are transported via air-freight to the Division of Biological Control in Albany for extraction and analysis. The microarthropods are extracted from the soil using a high heat gradient modified Tullgren funnel system. With the completion earlier this year of six additional funnel units, it is now possible to extract 96 sub-cores at one time, thus reducing cold storage time and increasing capacity. These systems use a combination of heat, light and drying action on the individual soil samples to drive the microarthropods from the soil core through steep walled plastic funnels sprayed with a dry silicone lubricant into alcohol filled vials where they are preserved for later analysis and counting. The temperature in the funnel units is controlled by a voltage regulator and increased gradually from an initial 90°F temperature to avoid excessively rapid heating and drying of the soil cores which could result in the microarthropods being killed in place, rather than being driven into the alcohol vial. Each core is extracted in the system for a minimum of three days depending on moisture content.

IV. Laboratory sample analysis

After extraction into alcohol vials, the microarthropods are counted under a dissecting scope. At the present time over 120 categories of soil microarthropods are being tabulated. A partial listing is as follows:

Insecta

Collembola
Protura
Campodeidae
Japygidae
Lepismatidae
Thysanoptera
Psocoptera
Hymenoptera
Diptera
Coleoptera
Formicidae
Rapnidiidae

Arachnida

Araneida
Chelonethida
Acarina

Myriapoda

Diplopoda
Chilopoda
Pauriopoda
Symphyla

Within the Acarina about 35 species of Cryptostigmatids, 30 species of Prostignotids and 10 species of Mesostigmatids are being counted separately. A representative reference collection is being developed for future use and comparison. The systematics of the majority of the above group, especially the Acarina,is poorly understood, but attempts will be made to identify the specimens to the greatest extent possible.

V. Data Retrieval, Management, and Analysis

In cooperation with Jim Barbieri of the Lawrence Livermore Laboratory, the standardized field data sheets for recording the distance, direction, and forest floor layer depth have been developed (Appendix A). In addition, the laboratory analysis data sheets, listing the taxonomic categories, acceptable abbreviations, and the appropriate counts for computer entry has been completed but is not yet available for duplication. The data already gathered in FY 74 are nowbeing transferred to these forms for key punching and entry into the data bank system in accordance with the procedures outlined in the Summary of the Protocol--1974. Using data similar to those which are being taken in this study, initial programs have been developed for computer analysis. These programs are capable of giving a complete listing of the data entered into the computer by date, sample, forest floor depth layer, and taxonomic category; of providing totals, means, and variances for each category for each sampling date, and for providing totals, means, and variances for specific summary taxonomic categories (Appendix B).

VI Results

It must be emphasized that these results are of a preliminary nature, cover only the first three sampling dates, include only a few taxonomic category combinations, and involve a relatively small sample size. They are intended to show possible trends only. As can be seen in Table 1, there seems to be a trend indicating more microarthropods in the forest floor under "healthy" trees than under "damaged" trees. (Note that the first two dates reflect trees at Snow Valley II and N. E. Green Valley only while the third date, 11-27-73, includes Breezy Point as well.) These differences could have been more pronounced but were modified by individual tree variation as indicated in Table 2. "Healthy" tree No. G618 had consistently fewer microarthropods than did "damaged" tree no. S785, and was only slightly higher than tree no. S753. One possible reason for this variation may be due to the fact that tree no. G618 was reportedly disturbed at least once by an off-road vehicle and that tree no. S785 is directly influenced by tree no. S784, a "healthier" tree (smog rating 19). Furthermore, for the one sample date, the "healthy" tree at Breezy Point (B394) had more microarthropods than did the "damaged" tree (B397). Table 3 gives a between plot comparison with the two trees on each plot combined. The trend here, consistent on all three dates, indicates that the very-slightly damaged plot, N. E. Green Valley had more microarthropods than moderately damaged plots. The Breezy Point plot, with a slightly higher oxidant damage rate than Snow Valley II, had a higher average number based primarily on the one "healthy" tree (B394).

VII. Discussion

There appears to be considerable between tree variation. It is hoped that the mapping, spacially and temporally, of each individual soil core and the associated forest floor depth measurements will indicate possible sources of this variation. Of primary importance to these studies will be the continued close coordination of the work with both the Litter Decomposition and Nutrient Cycling and the Soil Properties, Litter and Soil-Plant Climate Interaction research group.

TABLE 1

Comparison of Relatively Smog Damaged Trees (#753,785,397) with Relatively Healthy Trees (#614,618,394). Average Number/Sample - N=10

	8/16/73		10/4/73		11/27/73	
	Damaged	Healthy	Damaged	Healthy	Damaged	Healthy
Total Cryptostigmatid Adult	13.2	20.5	6.2	20.3	25.2	33.3
Total Cryptostigmatid Immature	7.7	11.6	3.0	11.2	2.9	6.8
Prostigmatid Adult	12.6	23.6	41.7	26.9	14.7	39.6
Miscellaneous Prostigmatids	24.6	36.2	7.7	52.4	12.9	17.2
Total Prostigmatids	37.5	60.0	49.3	79.3	27.6	56.9
Total Insecta	9.0	4.4	2.3	3.4	11.6	23.8
Combined Total	104.6	156.3	110.2	193.5	94.9	177.6

Table 2

Individual Tree Comparisons

Average No. of Taxonomic Category/Sample all Depths Combined N=10

	16 August 1973				4 October 1973				27 November 1973					
1973 Smog Rating	14	12	24	26	14	12	24	26	29	9	14	12	24	26
Tree No.	S753	S785	G614	G618	S753	S785	G614	G618	B394	B397	S753	S785	G614	G618
Total Cryptostigmatid adults	14.1	12.2	32.0	9.0	6.7	5.7	27.4	13.1	42.5	26.1	12.1	37.5	40.9	16.5
Total Cryptostigmatid immatures	7.9	7.4	14.2	9.0	0.8	5.1	15.1	7.2	5.7	3.0	1.5	4.2	10.8	4.0
Prostigmatid adult	5.8	19.4	17.7	29.4	25.6	57.7	21.1	32.6	9.7	9.6	16.1	18.5	91.4	17.8
Miscellaneous Prostigmatids	17.1	31.6	62.7	9.6	9.5	5.8	99.9	4.9	27.4	13.7	16.8	8.1	13.0	11.3
Total Prostigmatids	23.9	51.0	80.4	39.0	35.1	63.5	121.0	37.5	37.1	23.3	32.9	26.6	104.4	29.1
Total Mesostymatid adults	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.9	1.5	0.6	0.4	0.8	0.8
Mesostymatid immatures	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.5	1.3	0.0	0.5	0.6
Total Insects	5.9	12.0	5.0	3.8	1.8	2.8	4.2	2.6	43.2	15.0	4.8	15.0	18.1	10.1
Others	0.0	0.5	0.3	0.1	0.0	0.1	0.1	0.2	0.8	0.4	0.5	1.0	0.5	0.1
Combined Total	74.8	134.1	211.9	99.9	79.5	140.7	289.0	98.1	168.7	94.1	89.3	111.3	280.4	90.3

Table 2

Individual Tree Comparisons

Average No. of Taxonomic Category/Sample all Depths Combined N=10

	16 August 1973				4 October 1973				27 November 1973					
1973 Smog Rating	14	12	24	26	14	12	24	26	29	9	14	12	24	26
Tree No.	S753	S785	G614	G618	S753	S785	G614	G618	B394	B397	S753	S785	G614	G618
Total Cryptostigmatid adults	14.1	12.2	32.0	9.0	6.7	5.7	27.4	13.1	42.5	26.1	12.1	37.5	40.9	16.5
Total Cryptostigmatid immatures	7.9	7.4	14.2	9.0	0.8	5.1	15.1	7.2	5.7	3.0	1.5	4.2	10.8	4.0
Prostigmatid adult	5.8	19.4	17.7	29.4	25.6	57.7	21.1	32.6	9.7	9.6	16.1	18.5	91.4	17.8
Miscellaneous Prostigmatids	17.1	31.6	62.7	9.6	9.5	5.8	99.9	4.9	27.4	13.7	16.8	8.1	13.0	11.3
Total Prostigmatids	23.9	51.0	80.4	39.0	35.1	63.5	121.0	37.5	37.1	23.3	32.9	26.6	104.4	29.1
Total Mesostymatid adults	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.9	1.5	0.6	0.4	0.8	0.8
Mesostymatid immatures	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.5	1.3	0.0	0.5	0.6
Total Insects	5.9	12.0	5.0	3.8	1.8	2.8	4.2	2.6	43.2	15.0	4.8	15.0	18.1	10.1
Others	0.0	0.5	0.3	0.1	0.0	0.1	0.1	0.2	0.8	0.4	0.5	1.0	0.5	0.1
Combined Total	74.8	134.1	211.9	99.9	79.5	140.7	289.0	98.1	168.7	94.1	89.3	111.3	280.4	90.3

APPENDIX A.

FOREST FLOOR
DEPTH DATA (FFDD)

COLLECTED BY :

P.I : WENZ

Data Type : ____________ (1)

Plot I.D. : ____________ (2)

Tree #: ______ Color: ______ Date : ___|___|___ (3)

Sample	Dist.	Dirc.	Litter	Ferm	Humus	MinSoil	
1							(4)
2							(5)
3							(6)
4							(7)
5							(8)
6							(9)
7							(10)
8							(11)
9							(12)
10							(13)

Tree #: ______ Color: ______ Date : ___|___|___ (14)

Sample	Dist.	Dirc.	Litter	Ferm	Humus	MinSoil	
1							(15)
2							(16)
3							(17)
4							(18)
5							(19)
6							(20)
7							(21)
8							(22)
9							(23)
10							(24)

III-H

Effects of Air Pollutants on Litter Accumulation, Soil Properties, and Soil-Plant-Climate Interactions

Principal Investigator, Dr. R. J. Arkley
Co-Investigator, Dr. P. L. Gersper

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Oxidant Air Pollution Effects on a Western Coniferous Forest Ecosystem

University of California - U. S. Forest Service
Environmental Protection Agency

EPA Grant No. 88-02-0303

Title of Subproject

Effects of Air Pollutants on Litter Accumulation, Soil Properties, and Soil-Plant-Climate Interactions.

Annual Report: June 1973 - June 1974

Prepared by R. J. Arkley

Research Project III-H. Arkley, R. J. and P. L. Gersper

Effects of air pollutants on litter accumulation, soil properties and soil-plant-climate interactions.

General statement of objectives and accomplishments during 1973-74.

Activities during this year have been carried on mainly on the 18 major study plots located in the San Bernardino Mountains in such a manner that they are subject to varying intensities of oxidant air pollutant impact. These activities have been coordinated with other subprojects which also have much of their activity concentrated on these plots. Major objectives of this subproject have been to obtain base line information on 1) soil-plant-climate interactions by setting up a system for measuring soil moisture and temperature changes which can be related to the climate and pollutant monitoring subproject; 2) physical properties of the soils; 3) the production of litter-fall material by pine trees; and 4) the thickness and amount of the organic forest floor: all in relation to air pollutant impact.

Accomplishments during the year include: 1) determinations of the soil moisture and temperature regimes at 23 sites to a depth of 2.7 meters (9 feet) or to hard rock if shallower since July 1973 (since April 1973 at one site); 2) measurement of the effect of individual trees on the distribution of precipitation and crown-drip under 11 trees with smog impact rating ranging from very severe to very slight (essentially none); 3) measurement of litter production in relation to pollutant injury; 4) measurements of the thickness of the forest floor on disturbed and undisturbed areas of 14 plots; 5) measurements of the pattern of thickness of the forest floor under 18 individual pine trees variously impacted by smog; 6) the correlation between depth and weight of the forest floor was tentatively established using 28 large core samples; 7) the particle size distribution and pH of the soils at all soil moisture-temperature sites was determined.

Research Progress:

1. Soil moisture-temperature studies:

Fibreglass moisture-temperature blocks were installed at 23 sites at depths of 15, 30, 61, 91, 152, 213, 274 cm. where the depth to hard rock would permit. Installation was in a 9.0 cm. auger hole repacked with the original soil to the same density as originally present. Wires extending to the surface were connected to an A.C. millivolt meter at weekly or biweekly intervals and readings taken. To convert the readings to moisture content and temperature, the data were read into a computer program which outputs temperature and resistance due to moisture (corrected for temperature). Soil samples were collected from duplicate 9 cm. cores taken within 1.5 meters of the sites and were calibrated by relating soil moisture content to the corrected moisture-block resistance. As of June 1, 120 soil samples had been calibrated. The calibration procedure, which involves gradual drying of the saturated sample containing a moisture-temperature block, requires about a week or 10 days for 10 samples.

Also, cores were taken for volumetric water content of the soils at each site, both at the driest period (September) and the wettest (April or early May) after the snow had melted. This information together with the moisture-block data should provide all the information necessary to describe the moisture regime of the soils, the rate of evapotranspiration and the period of moisture stress on the plants.

Results: The sampling for volumetric soil moisture content indicates that the available soil moisture storage capacity of these soils, which are formed on decomposed granite for the most part, is considerably higher than anticipated considering their generally coarse texture. Values range up to 40 cm. (16 inches) to a depth of 274 cm. (9 feet) and the moisture blocks confirm that soil moisture continues to be removed by transpiration to this depth until late in October when the first significant precipitation began. This soil moisture storage capacity is much higher than is commonly estimated for calculating the water balance by Thornthwaite's procedure. Perhaps this is due to the xeric nature of the climate with its long dry summers which have forced the trees into extending their roots deeply.

2. Biohydrology studies.

To investigate the effect of trees variously affected by pollutants on the pattern of precipitation reaching the soil surface, and the concentration of dissolved material in the "crown drip", a total of 209 cans of 9.9 cm. diameter were installed on stakes about 40 cm. above the soil surface, under 11 trees, ranging in smog injury ratings of 0.0 (dead) and 3.0 (very severe) to 34.0 (very slight). The "crown drip" collectors were arranged under isolated trees along radial lines selected at random, at intervals of 0, .5, 1.0, 1.5, 2.0, 3.0, 4.0 ..... X meters from the edge of the tree trunk at ground level.

Liquid caught in the cans was collected on December 5, 1973 after the first major storm of the season which occurred November 17, 18 (105. mm. at Lake Arrowhead) plus 7 mm. on November 29; part of the precipitation was as snow or sleet. The volume of liquid was measured and samples analysed for concentration of sodium and potassium by absorption flame photometry.

Results: Under six of the trees, the volume of crown drip declined linearly with distance from the stem, with correlation coefficients of -0.83 to -0.90. The average depth of liquid caught under trees at the Camp O'Ongo site (COO) was 25.0 mm. and at the U. C. Conference Center site (UCC) was 30.6 mm. Snow gauge data from the same sites indicate that the total precipitation was 83. mm. at UCC and 69. mm. at COO. The maximum "crown drip" under any tree at UCC was 98.0 mm. and at COO was 66.3 mm. Thus in this first storm, there was a great deal of interception by the trees. The ratio of crown drip to snow gauge depths is 0.36 at both sites.

The average amount of sodium and potassium found in the collectors under 11 trees was 42.1 and 65.7 mg/M^2. No clear relationship between the amount or concentration of these elements in the crown drip and the smog damage ratings of the trees was found. However, more statistical analysis is necessary before definite conclusions can be drawn. These studies were only preliminary, and will be continued in the future.

3. Litter production studies:

Litter collection screens were emplaced in September and collected in early December 1973. Screens were simply squares of 1/4 inch wire mesh pinned down with wire hooks to the soil surface. The litter was oven dried at 70° C. for 48 hours and weighed. Then a large number of needle fascicles were counted and the mass per fascicle determined. The screens were located beneath the canopies of trees for which the smog injury scores had been determined by others.

A total of 34 screens which had been undisturbed by vacationers were collected at 12 sites. Omitting one site which was clearly aberrant for some reason, it was found that the average amount of litter production increased with decreasing smog injury, with a correlation coefficient of 0.55. This was encouraging, but even better, it was found that the mass of needle fall per fascicle increased with decreasing smog injury with a correlation coefficient of 0.96 for all but 4 sites. Thus it may be concluded that the average mass of needles per fascicle in the litter fall may be a good measure of smog injury.

4. Forest floor studies:

a. Plot transects.

The thickness of the organic forest floor was measured along the center line of 14 study plots at 2. meter intervals. It was found that areas disturbed by logging or recreation activity had a much thinner forest floor than undisturbed areas. The ratio of thickness of undisturbed to disturbed areas ranged from 2.52 to 4.48. Data are given in Appendix Table 4.

b. Pattern of forest floor thickness under individual trees.

Under 17 trees of varying smog injury, the pattern of depth of forest floor was determined by measuring its thickness at 0.5 meter intervals in four directions from the tree stem. Where the trees were sufficiently isolated from others, the thickness of forest floor clearly declined linearly with distance from the tree stem; statistics are incomplete on this data but in one case the average thickness declined from 15.5 cm. at 0.5 M. to 1.8 cm. at 4.5 M. The correlation coefficient was -0.98 and the regression line was represented by:

$$\text{Thickness (cm)} = -.0329\ \text{Distance (cm)} + 16.57$$

Computer programs are being developed for calculating the total weighted average volume of forest floor under these trees.

c. Weight of forest floor versus thickness.

In order to determine the validity of the forest floor thickness measurements as as a measure of the mass of forest floor a number of core samples of the forest floor were collected, the thickness measured and their air dry weight determined. Except for three aberrant samples, it was found that the mass was correlated with thickness with a correlation coefficient of 0.93 and that the mass was equal to approximately 1.34 kg/M^2 per cm. of thickness. When more fully validated by more sample collections, this kind of relationship can be used effectively for estimating the total mass of forest floor under trees variously affected by smog, by simply measuring the thickness of the forest floor, as well as the total mass of the forest floor on entire plots subject to varying impact of pollutants.

5. Particle size distribution of soil profiles and soil pH.

The particle size distribution was determined on 114 samples taken from 22 of the soil cores collected for total moisture content in the Fall of 1973. The gravel and sands were determined by seiving and the silt and clay content by the hydrometer method using sedimentation rate columns. The fine and coarse gravel content was determined on all of the core samples (an additional 69 samples) for use in the volumetric soil moisture studies. The pH was determined on all samples as well. Six of the profiles show a clay accumulation horizon (Bt), 5 of these are in the vicinity of Lake Arrowhead and 1 is located at Holcomb Valley in a relatively dry area north of Big Bear Lake. The other 16 profiles show no Bt horizon in the clay data. The pH data of soils with Bt horizons show the minimum pH in the Bt horizon to be between 5.3 and 5.6 except for Holcomb Valley where the pH is 6.1. The remaining soils have a minimum pH in the upper 122 cm. of soil of 5.0 to 6.1 except for one profile from alluvium derived from mixed rock sources which has pH values ranging from 7.1 to 8.3; this profile evidently contains some limestone in the profile.

Relationship to overall project.

The soil moisture and temperature studies are directly related to the project at the tree level of interactions (Item 25a and 20a, P. 18 of the Protocol - Renewal 1974), at the community level (Item 3, P. 20) and at the stand level of interactions (Item 16a, P. 24).

Biohydrology studies are involved in the same interactions plus interactions involving animal and microbial activity in the forest floor and soil surface at the tree level of interaction.

Studies of litter production and the forest floor are related to microbial and insect activities at the community level (Items 12, P. 10; 13, 17, 18, 21, 22, P. 21).

Soil characteristics studies of soil particle size distribution and pH have been carried on primarily at the community (plot) level and are related to small mammal studies (Item 11, P. 20), insects (Item 13, P. 21) and microorganisms (pathogens) (Item 18, P. 21). This work will be extended to individual tree studies in the future.

Thus these studies are intimately connected with almost all other phases of the overall project.

III-I

REPRODUCTIVE BIOLOGY OF CERTAIN CONIFEROUS COMPONENTS OF THE SAN BERNARDINO MOUNTAIN ECOSYSTEM

Coniferous Cone and Seed Production

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Riverside, California 92502

Progress Report - Cone Production

Cone production for Ponderosa, Jeffrey and Sugar Pines was recorded in fifteen of the eighteen plots last year. Cone production for these pines is summarized in Table I. As expected, the dominant crown tree class produced the greatest number of cones: 72% of the trees that produced cones were dominant and these produced 85% of the cones recorded. These observations agree with what has been generally known about cone crops in pine.

The two plots producing the greatest number of cones were Camp Angeles and Tunnel Two. These heavy crops were the result of 7 trees producing a large number of cones. For example, 3 trees (numbers 15, 67, and 79) at Camp Angeles produced 917 cones (75.4%) while, at Tunnel Two, 4 trees (numbers 415, 419, 453, and 479) produced 1,333 cones (85.6%).

Interplot comparisons of cone production are unwarranted with only a single year of data. Qualitative observations, however, suggest that a large part of interplot differences can be explained by tree age (size) and by tree species. Thus, additional data on each tree are being taken with respect to height, length of live crown, age of each tree, etc. An example of the type of data obtained is that provided by the data sheets for Sky Forest (S.F.).

The greatest single loss of second year cones is that attributable to squirrels. This loss is predominantly in plots containing Ponderosa Pine. Less than 1% of the pine seed produced is lost to cone moths. This moth has been tentatively identified as a Lasperysia and has only been recovered from Jeffrey pine cones.

The distribution of the number of seeds produced per cone is being determined for each plot. An example is provided in Figure 1. These distributions will be used for inter- and intra-plot comparisons and for developing cone production distributions.

Table I. Summary of 1973 cone production on pines by plot.

		DOMINANT		CODOM		INTER		INTER-OPEN	
Plot I.D.	Tree sp	# trees w/cones	Total # cones	# trees w/cones	Total # cones	# trees w/cones	Total # cones	# trees w/cones	Total # cones
Bluff Lake	P.J.	8	69	4	27	0	0	0	0
Breezy Point	P.P.	1	1	0	0	0	0	0	0
Camp Angeles	P.P.	9	1216	6	174	0	0	1	8
Camp Pavika	P.P.	2	4	0	0	0	0	0	0
Dogwood	S.P.	0	0	2	86	0	0	0	0
Green Valley Creek	P.J.	21	447	0	0	0	0	0	0
Green Valley Creek	P.C.	1	1	0	0	0	0	0	0
Hart Bar	P.J.	5	16	1	2	0	0	0	0
N.E. Green Valley	P.J.	10	103	6	30	2	7	0	0
Camp O-onoga	P.P.	3	9	0	0	0	0	0	0
Sand Canyon	P.J.	15	219	6	93	0	0	1	1
Sky Forest	P.P.	16	99	5	12	0	0	1	1
Snow Valley II	P.J.	7	29	5	33	0	0	1	2
Tunnel 2	P.P.	14	1558	5	207	0	0	0	0
Tunnel 2	S.P.	1	7	0	0	0	0	0	0
Tunnel 2	P.C.	[illegible]	5	0	0	0	0	0	0
[illegible] C. Conference Grounds	P.P.	[illegible]	3	0	0	0	0	0	0
Barton Flats	P.P.	0	0	1	8	0	0	0	0
Total		118	3786	41	672	2	7	4	12
% of total cones (1) % of total tree (2)		71.6%	84.6%	24.8%	15.0%	1.2%	0.2%	2.4%	0.3%

(1) Total cones 4477
(2) Total tree producing cones 165

CONE - TREE DATA

EPA-SBNF Ecosystem Project

R. Luck, P.I.

Data Type : C. TREE (1)
Plot I.D. : SF (2)
Date : 11/5/73 (3)
Number of Days: Two (4)
Page : 1 of 11 (5)

Tree Number	Color	Species	DBH	Apparent Ht.	Apparent Crown Ht.	Slope	Crown Class		Comments
1234		PP	45.1	108	84	14.5	D	(6)	Unopened cones
1235		IC	9.2	37	36	16.0	IO	(7)	
1236		BO	8.1 6.0	--	--	--	CD	(8)	
1237		IC	13.3	51	47	12.0	CD	(9)	
1238		CONU	--	--	--	--	CD	(10)	Multiple trunks
1239		IC	15.0	46	39	8.0	CD	(11)	
1240		CONU	--	--	--	--	I	(12)	Multiple trunks
1241		IC	38.4	98	92	19.0	D	(13)	
1242		IC	8.4	29	29	18.0	IO	(14)	
1243		IC	7.6	--	--	--	IS	(15)	
1244		PP	26.5	85	40	1.0	CD	(16)	
1245		PP	25.8	77	32	5.0	CD	(17)	
1246		IC	6.1	29	20	0.0	I	(18)	
1247		CONU	5.0	15	13	3.0	I	(19)	
1248		WF	4.5	21	21	16.0	I	(20)	
1249		PILA	5.1	23	23	16.0	I	(21)	
1250		PILA	6.8	27	27	14.0	IS	(22)	
1251		PP	27.5	104	47	15.0	CD	(23)	
1252		WF	6.9	29	24	15.0	IS	(24)	
1253		WF	12.2	63	56	16.0	IO	(25)	
1254		PP	22.8	79	66	10.0	CD	(26)	
1255		PP	24.7	96	31	14.0	I	(27)	
1256		PP	29.8	96	41	5.0	CD	(28)	

CONE - TREE DATA

EPA-SBNF Ecosystem Project

R. Luck, P.I.

Data Type : C. TREE (1)
Plot I.D. : SF (2)
Date : 11/5/73 (3)
Number of Days: Two (4)
Page : 2 of 11 (5)

Tree Number	Color	Species	DBH	Apparent Ht.	Apparent Crown Ht.	Slope	Crown Class		Comments
1257		PILA	6.7	25	24	14.0	I	(6)	
1258		PP	25.5	109	48	11.0	D	(7)	
1259		PP	29.2	98	30	5.0	D	(8)	
1260		PP	31.5	101	60	2.0	D	(9)	1 closed
1261		WF	7.8	87	23	16.0	I	(10)	
1262		PILA	13.0	52	50	9.0	IO	(11)	
1263		PILA	5.0	20	17	6.5	I	(12)	
1264		PILA	6.9	21	27	12.0	I	(13)	
1265		PP	30.3	100	45	0.0	D	(14)	
1266		PILA	8.7	31	26	1.0	I	(15)	
1267		WF	4.8	21	16	3.0	IS	(16)	
1268		PP	29.0	102	31	5.0	D	(17)	
1269		WF	8.8	36	30	9.5	IO	(18)	
1270		WF	9.8	45	41	3.0	I	(19)	
1271		WF	12.1	57	52	9.0	I	(20)	
1272		PILA	5.8	32	28	13.0	I	(21)	
1273		WF	6.3	32	26	13.0	I	(22)	
1274		PILA	4.1	25	19	14.0	IS	(23)	
1275		PP	34.7	120	97	16.0	D	(24)	
1276		WF	5.9	27	24	16.0	IS	(25)	
1277		BO	6.8	--	--	--	IO	(26)	
1278		IC	5.7	22	20	1.0	IS	(27)	
1279		WF	6.1	33	33	2.0	I	(28)	

CONE & SQUIRREL DATA

EPA - SBNF Ecosystem Project

R. Luck, P.I.

Data Type : CONE (1)
Plot I.D. : SF (2)
Date : 11/5/73 (3)
Number of Days: Two (4)
Page : 1 of 11 (5)

Tree Number	Color	5'	10'	15'	20'	25'	30'	35'	40'	45'	50'	Number of Squirrel Cones on round	
1234		0	0	1	1	1	0	0	0			0	(6)
1235		0	0	0	→							0	(7)
1236		0	0	0	→							0	(8)
1237		0	0	0	→							0	(9)
1238		0	0	0	→							0	(10)
1239		0	0	0	→							0	(11)
1240		0	0	0	→							0	(12)
1241		0	0	0	→							0	(13)
1242		0	0	0	→							0	(14)
1243		0	0	0	→							0	(15)
1244		0	0	0	→							0	(16)
1245		0	0	0	→							0	(17)
1246		0	0	0	→							0	(18)
1247		0	0	0	→							0	(19)
1248		0	0	0	→							0	(20)
1249		0	0	0	→							0	(21)
1250		0	0	0	→							0	(22)
1251		0	0	0	→							0	(23)
1252		0	0	0	→							0	(24)
1253		0	0	0	→							0	(25)
1254		2	0	0	0	→						0	(26)
1255		0	0	0	→							0	(27)
1256		0	0	0	→							0	(28)

CONE & SQUIRREL DATA

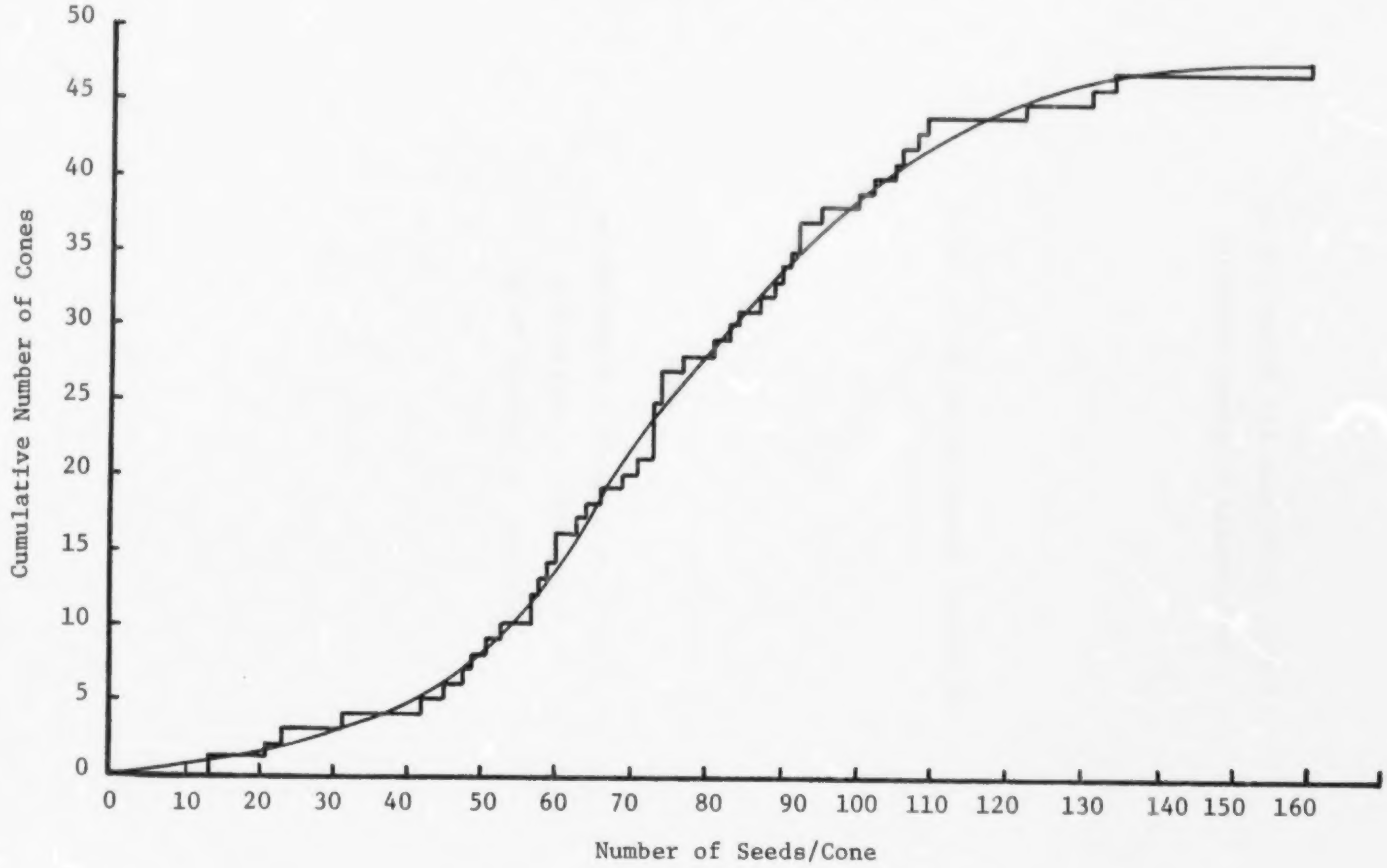
EPA-SBNF Ecosystem Project

R. Luck, P.I.

Data Type : CONE (1)
Plot I.D. : SF (2)
Date : 11/5/73 (3)
Number of Days: Two (4)
Page : 2 of 11 (5)

Tree Number	Color	5'	10'	15'	20'	25'	30'	35'	40'	45'	50'	Number of Squirrel Cones on round	
1257		0	0	0	→							0	(6)
1258		0	0	0	→							0	(7)
1259		0	0	0	→							0	(8)
1260		0	1	0	2	0	0	0	→			0	(9)
1261		0	0	0	→							0	(10)
1262		0	0	0	→							0	(11)
1263		0	0	0	→							0	(12)
1264		0	0	0	→							0	(13)
1265		0	0	0	→							0	(14)
1266		0	0	0	→							0	(15)
1267		0	0	0	→							0	(16)
1268		0	0	0	→							0	(17)
1269		0	0	0	→							0	(18)
1270		0	0	0	→							0	(19)
1271		0	0	0	→							0	(20)
1272		0	0	0	→							0	(21)
1273		0	0	0	→							0	(22)
1274		0	0	0	→							0	(23)
1275		0	0	0	0	0	0	0	1	0	0	0	(24)
1276		0	0	0	→							0	(25)
1277		0	0	0	→							0	(26)
1278		0	0	0	→							0	(27)
1279		0	0	0	→							0	(28)

Figure 1. Cumulative frequency distribution of the number of seeds/cone.



III-K

Effect of Oxidant Air Pollutants on the Vertebrate Animal Community

Principal Investigator, Dr. M. White

School of Forestry & Conservation
University of California
Berkeley, California 94720

TERRESTRIAL VERTEBRATE COMMITTEE

SUMMARY OF 1973 ACTIVITIES

Introduction

The Terrestrial Vertebrate Committee spent approximately six weeks in the field during the summer of 1973, from 16 August until 21 September. Field work emphasized the continuation of the inventory of small mammal populations. Delays in initiating the summer field work caused us to restrict our summer goals from those stated in the Task C report. Detailed study of common resident birds was postponed. As time allowed, we gathered data on utilization of cones and seeds by small mammals, particularly the western gray squirrel (Sciurus griseus).

Small Mammal Trapping

A. Background:

Initial small mammal snap-trapping was carried out in the summer of 1972 (Kolb and White 1974). The trapping was done on six permanent study plots established jointly by the various committees involved in the study. Calhoun Type B lines (Calhoun 1959) were employed. 20 trap stations containing three Museum Specials were spaced at 50-foot intervals along a 1000-foot transect. In most cases, "Calhoun lines" ran parallel with the longitudinal edges of each plot (Fig. 1). Permanent trap line markers of 3/8-inch x 3-feet reinforcement bar were placed at each station along the lines. A number-letter combination identification was assigned to each. Four of the six original small mammal study plots -- Dogwood, Barton Flats, Heart Bar, and Sand Canyon -- were re-trapped in 1973 using the same trap stations that were used in 1972. The Snow Valley plot was relocated in 1973

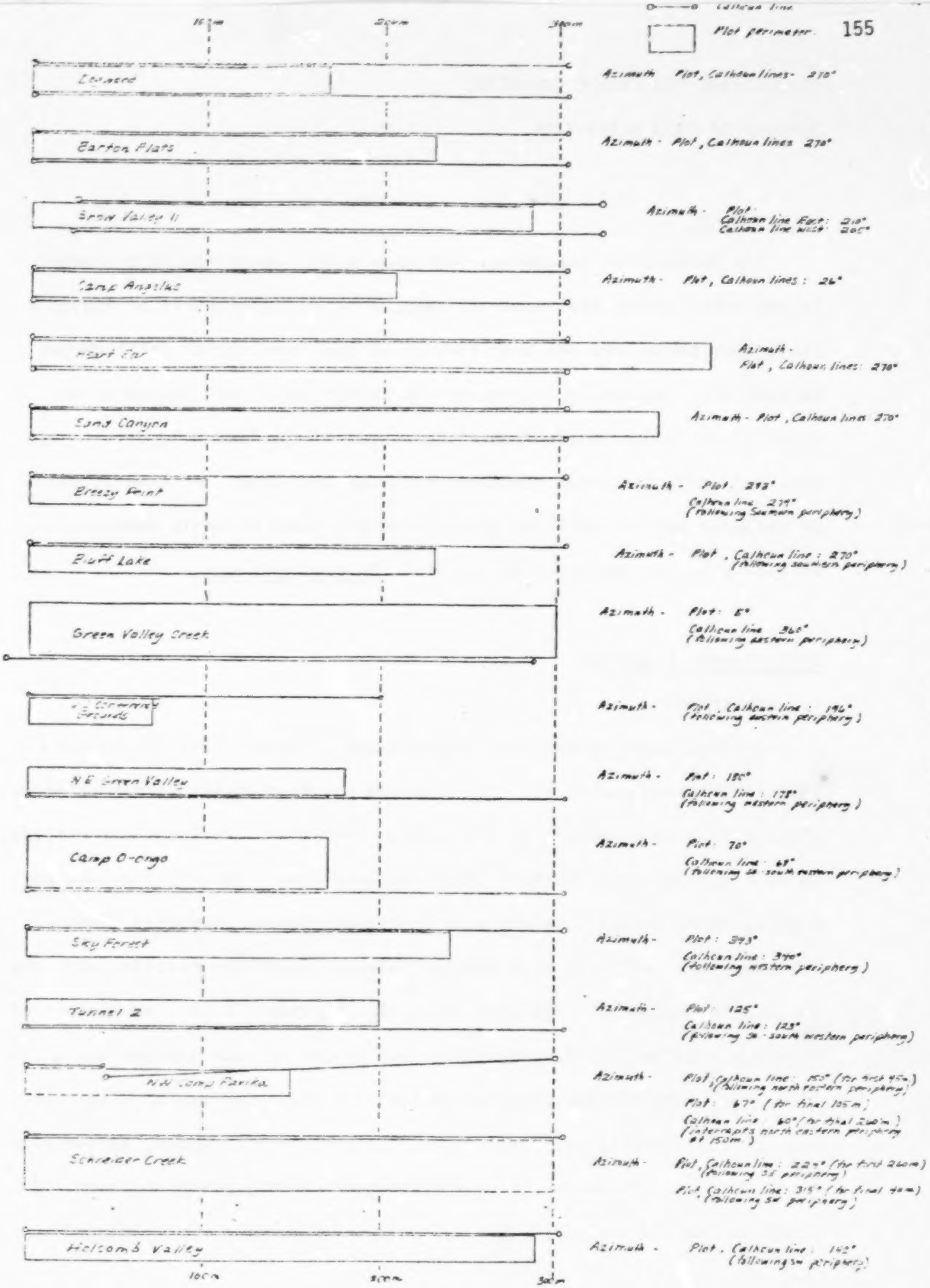

Calhoun line
Plot perimeter
100m
200m
300m
Leonard
Azimuth Plot, Calhoun lines- 270°
Barton Flats
Azimuth - Plot, Calhoun lines 270°
Snow Valley II
Azimuth - Plot:
Calhoun line East: 210°
Calhoun line West: 205°
Camp Angelus
Azimuth - Plot, Calhoun lines: 26°
Heart Bar
Azimuth -
Plot, Calhoun lines: 270°
Sand Canyon
Azimuth - Plot, Calhoun lines 270°
Breezy Point
Azimuth - Plot 272°
Calhoun line 279°
(following Southern periphery)
Bluff Lake
Azimuth - Plot, Calhoun line: 270°
(following southern periphery)
Green Valley Creek
Azimuth - Plot: 5°
Calhoun line 360°
(following eastern periphery)
N.E. Community Grounds
Azimuth - Plot, Calhoun line: 196°
(following eastern periphery)
N E Green Valley
Azimuth - Plot: 180°
Calhoun line: 178°
(following western periphery)
Camp O-ongo
Azimuth - Plot: 70°
Calhoun line: 68°
(following se south eastern periphery)
Sky Forest
Azimuth - Plot: 343°
Calhoun line: 340°
(following western periphery)
Tunnel 2
Azimuth - Plot: 125°
Calhoun line: 123°
(following sw south western periphery)
NW Camp Paivika
Azimuth - Plot, Calhoun line: 150° (for first 45m)
(following north eastern periphery)
Plot: 67° (for final 105m)
Calhoun line: 60° (for final 240m)
(intercepts north eastern periphery at 150m)
Schneider Creek
Azimuth - Plot, Calhoun line: 227° (for first 260m)
(following SE periphery)
Plot, Calhoun line: 315° (for final 40m)
(following SW periphery)
Holcomb Valley
Azimuth - Plot, Calhoun line: 162°
(following sw periphery)
100m
200m
300m

Fig. 1. Placement of small mammal trap lines on 17 plots.

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because of topographical and habitat irregularities. The Camp Angelus station markers were removed sometime after cessation of trapping in 1972 and before the 1973 field season. However, plot location notes filed by James Kolb in 1972 allowed us to re-establish the Camp Angelus trap line in apparent similitude to the original lines. As testimony to the 1973 line's replication of the original, we found four 1972 station markers along the transects we re-established in 1973.

B. 1973 Procedure:

At 0800 on 21 August Chris Chouteau and Ken McDonald set traps at the 40 stations on the Dogwood study plot. Hold Fast rat traps were added to the trap lines, so that each station in 1973 contained one rat trap and two Museum Specials. All trapping procedures employed in 1972 were repeated in 1973. Traps were baited with peanut butter and placed within 10 feet of the station marker. Adequate trap protection and concealment figured most prominently in the placement of the traps within the 10-foot radius. Trap lines were run for three consecutive days. Approximately 36 hours of daylight trapping and 36 hours of night trapping afforded equal opportunity for capture of both diurnal and nocturnal small mammals. Each trap was checked in the early morning and again in the early evening.

We established 11 new small mammal trap lines in 1973 (Fig. 1). Using the same procedure as that described for the 1972 study, we established one permanent trap line on 11 of the 12 plots designated and laid out prior to the 1973 field season. The first of the new plots to be trapped was

Schneider Creek. A Calhoun line was staked out on 3 September and set with 60 traps. On 11 September a 60-trap Calhoun line was staked out on Northwest Camp Pavika. These two plots represent the only small mammal plots in the forest on which the trap lines do not run along the longitudinal edges of the general study plot (Fig. 1). In both cases, the non-rectangular nature of the plot precluded use of a linear trap line within the study plot boundaries.

C. Results:

On the 16 plots, 1290 traps were set for 3-day periods between 21 August and 17 September. 39 traps were set on UC Conference Grounds on 17 September for 2 days. On 19 September a private logging operation destroyed 9 traps, leaving 30 traps set for the final day. In total, 3978 trap-days were employed on the 17 plots. 93 small mammals were collected giving a 2.34 percent capture rate (Table 1). Deer mice (Peromyscus spp.) accounted for 37.6 percent of the total number of animals trapped. Chipmunks (Eutamias speciosus and E. merriami) accounted for 21.5 percent of the total number. Dusky-footed woodrats (Neotoma fuscipes) and golden-mantled ground squirrels (Spermophilus lateralis) each accounted for 14.0 percent of the total number trapped. 70 percent of the total catch came from just four plots: Snow Valley II, Sand Canyon, Heart Bar, and Northeast Green Valley.

Fewer small mammals were trapped overall on the six old plots in 1973 than in 1972 (Table 2). Snow Valley, Sand Canyon, and Heart Bar account for the highest catch in both years, but the 1973 totals were lower than 1972 totals on these three plots. Figure 2 shows the comparison between trapping

Table 1. 1973 small mammal trapping results for 17 study plots.

No. traps	Plot & trap period	*Peromyscus* sp.	*E. merriami*	*E. speciosus*	*M. californicus*	*N. Fuscipes*	*S. lateralis*	*G. sabrinus*	*S. beecheyi*	No. caught
108	Dogwood 1700/21 Aug.- 1600/24 Aug.	1								1
117	Snow Valley II 1700/22 Aug.- 1615/25 Aug.	4	8			2	7		1	22
120	Heart Bar 0900/27 Aug.- 0800/30 Aug.	2	3		3	3	3			14
120	Sand Canyon 0800/27 Aug.- 0900/30 Aug.	5	3			8	1		1	18
120	Camp Angelus 0900/3 Sept.- 0900/6 Sept.	3					1	1		5
60	Barton Flats 1000/3 Sept.- 1600 /7 Sept.	1								1
60	Schneider Creek 1130/3 Sept.- 1030/6 Sept.									0
60	Holcomb Valley 1600/ 18 Sept.- 1100/21 Sept.	4					1			5
60	N. E. Green Valley 0830/17 Sept. 0900/20 Sept.	5		3	3					11
60	Tunnel 12 1500/11 Sept.- 1700/14 Sept.	1								1
60	Bluff Lake 1700/18 Sept.- 1100/21 Sept.	2						1		3

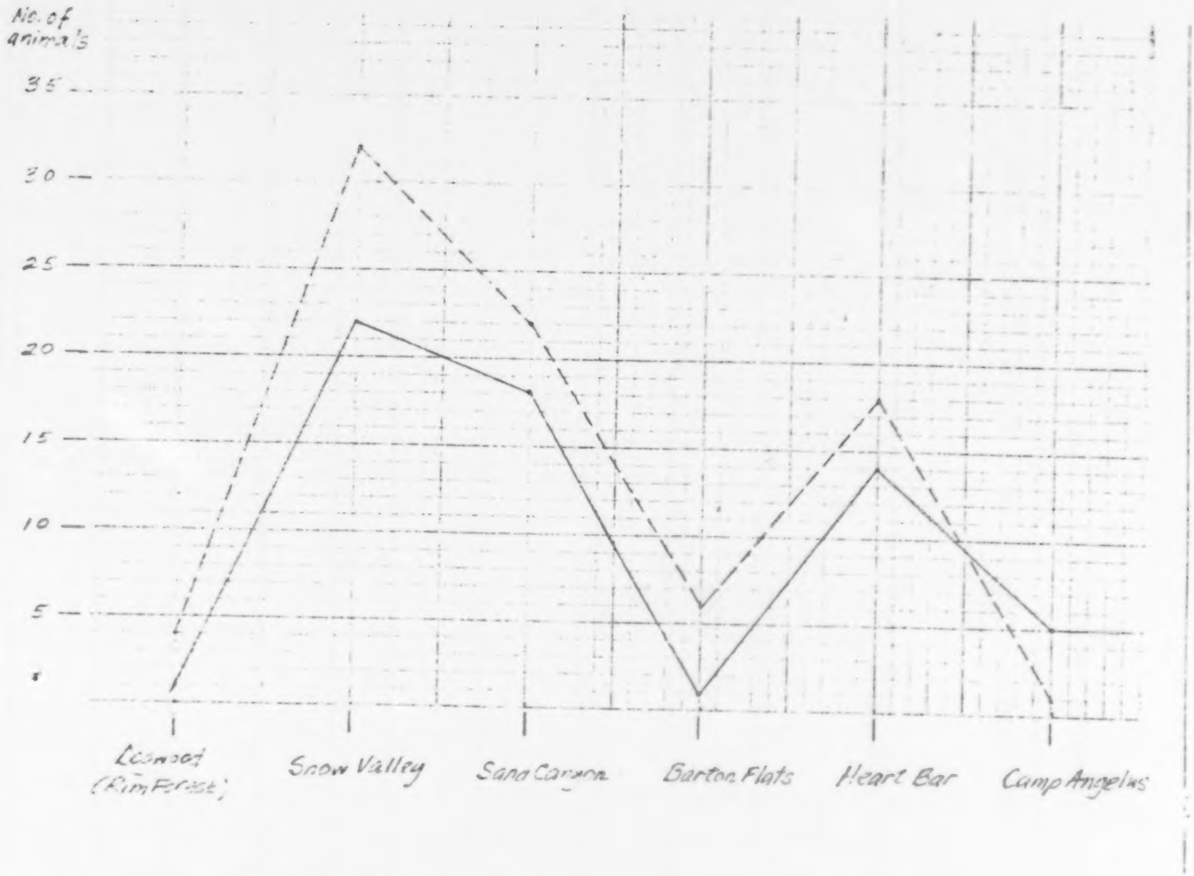
Table I. (Continued)

No. traps	Plot & Trap period	*Peromyscus* sp.	*E. merriami*	*E. speciosus*	*M. californicus*	*N. Fuscipes*	*S. lateralis*	*G. sabrinus*	*S. beecheyi*	No. caught
60	NW Camp Pavika 1400/11 Sept.- 1600/14 Sept.	1						1		2
51	Sky Forest 1750/11 Sept.- 1830/14 Sept.									0
39	UC Conf. Grounds 1230/17 Sept.- 1300/20 Sept.		1	1						2
60	Green Valley Creek 1010/17 Sept.- 1000/20 Sept.	3		1						4
60	Breezy Point 1100/11 Sept.- 1000/14 Sept.	3								3
54	Camp O-ongo 1125/17 Sept.- 1030/20 Sept.				1					1
	No. animals caught	35	15	5	7	13	13	3	2	Total 93

Table 2. Comparison of 1972 and 1973 small mammal trapping results.

	Dogwood- (Rim Forest)		Snow Valley		Sand Canyon		Heart Bar		Barton Flats		Camp Angelus		Totals	
			I	II										
Year:	72	73	72	73	72	73	72	73	72	73	72	73		
SPECIES:														
Peromyscus sp.	1	1	24	4	11	5	5	2	3	1	1	3	72 73	45 16
E. merriami	3	0	1	8	8	3	7	3	0	0	0	0	72 73	19 14
M. californicus	0	0	5	0	0	0	0	3	2	0	0	0	72 73	7 3
N. fuscipes	0	0	2	2	3	8	0	3	0	0	0	0	72 73	5 13
E. Speciosus	0	0	0	0	0	0	3	0	0	0	0	0	72 73	3 0
D. agilis	0	0	0	0	0	0	1	0	0	0	0	0	72 73	1 0
S. ornatus	0	0	0	0	0	0	0	0	1	0	0	0	72 73	1 0
S. lateralis	0	0	0	7	0	1	2	3	0	0	0	1	72 73	2 12
G. sabrinus	0	0	0	0	0	0	0	0	0	0	0	1	72 73	0 1
S. beecheyi	0	0	0	1	0	1	0	0	0	0	0	0	72 73	0 2
Plot Totals:	4	1	32	22	22	18	18	14	6	1	1	5		

Small mammal 1972 Total: 83
" " 1973 Total: 61



1972 --------

1973 ________

Fig. 2. Comparison of 1972 and 1973 small mammal trapping results by plot.

results in 1972 and 1973 by plot. Except for the Camp Angelus increase all plots yielded uniformly fewer animals in 1973. The greatest reduction occurred in deer mouse numbers (45 trapped in 1972: 16 trapped in 1973) as shown in Figure 3. Notable increases in the catch of woodrats and ground squirrels occurred in 1973. 5 dusky-footed woodrats were caught in 1972, 13 were caught in 1973. Two ground squirrels were captured in 1972, 14 in 1973. These are relatively large animals, whose presence in 1973 collections can most probably be attributed to addition of rat traps. The reduction in deer mouse numbers apparently correlates with the scarcity of deer mice in several areas of the Sierra in 1973.

The 11 plots trapped for the first time in 1973 yielded 32 small mammals in 1863 trap-days. This is a capture rate of 1.73 percent, significantly lower than both the 1972 and 1973 old plot results.

D. Discussion:

1972 findings show that overall more animals were caught on plots least affected by oxidant air pollution . Similarly, in 1973 the plots least affected by oxidant air pollution (Table 3) yielded the greatest number of animals (Figure 4). Differences in the catch of small mammals also appears to be correlated with the amount of understory vegetation on the plots. Snow Valley II, for example, has a relatively large amount of perennial brush cover (*Ceanothus leucodermis*, *Arctostaphylos parryana*, *Chrysothamnus nauseosus*, *Cercocarpus ledifolius*). Barton Flats, Dogwood, and Camp Angelus have relatively little perennial brush cover. Much of the low lying vegetation layer on Barton Flats is bracken fern (*Pteridium aquilinum*)which, although a perennial, dies back to the rhyzome crown in

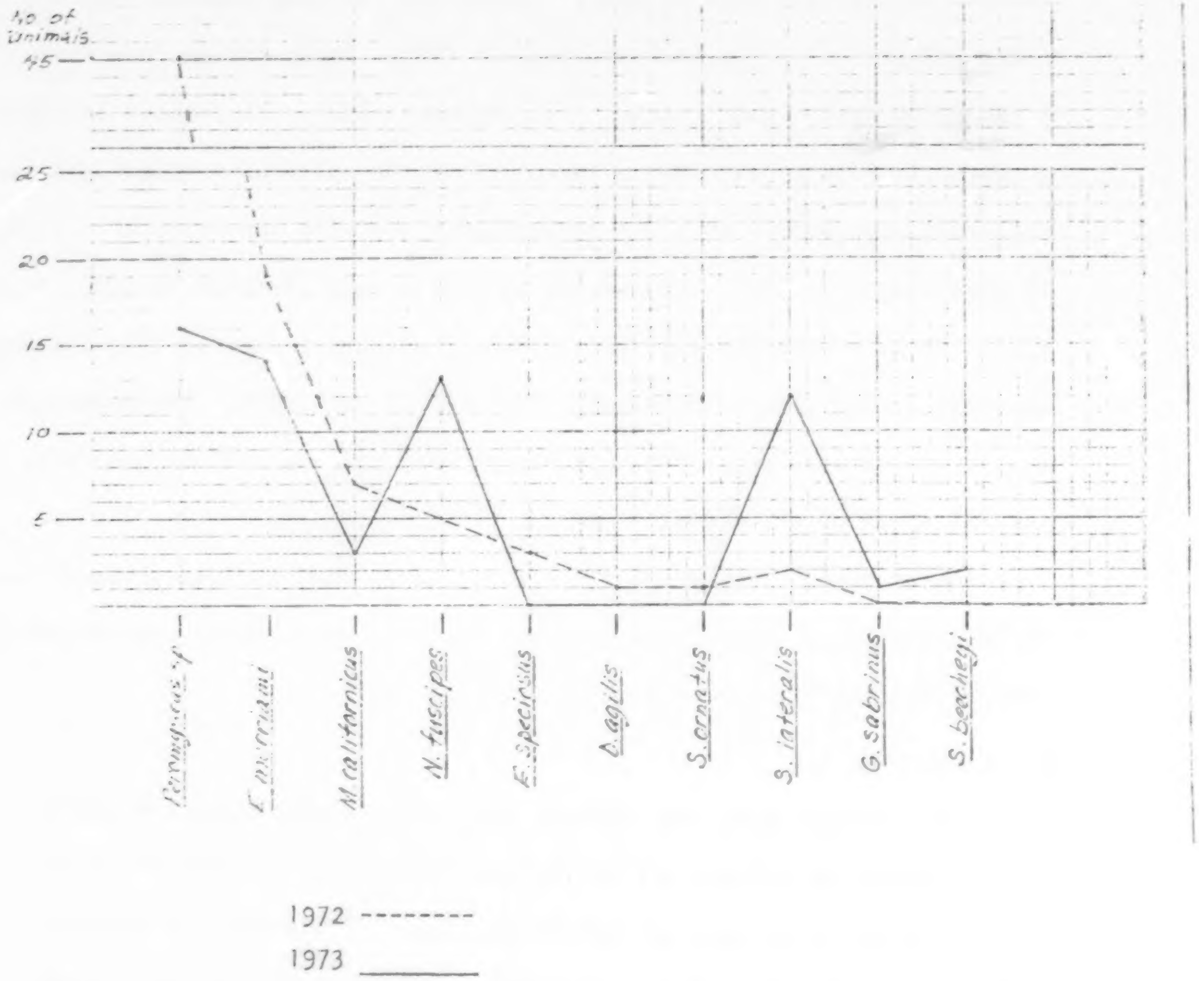


Fig. 3. Comparison of 1972 and 1973 small mammal trapping results by species.

Table 3. Grouping by oxidant level of 17 small mammal study plots.

Light Oxidant level

Heart Bar
Sand Canyon
Holcomb Valley
NE Green Valley
Tunnel 2
Bluff Lake

Moderate Oxidant level

Snow Valley II
Barton Flats
Schneider Creek
U. C. Conference Grounds
Green Valley Creek
Breezy Point

Heavy Oxidant level

Dogwood
Camp Angelus
NW Camp Pavika
Sky Forest
Camp O-ongo

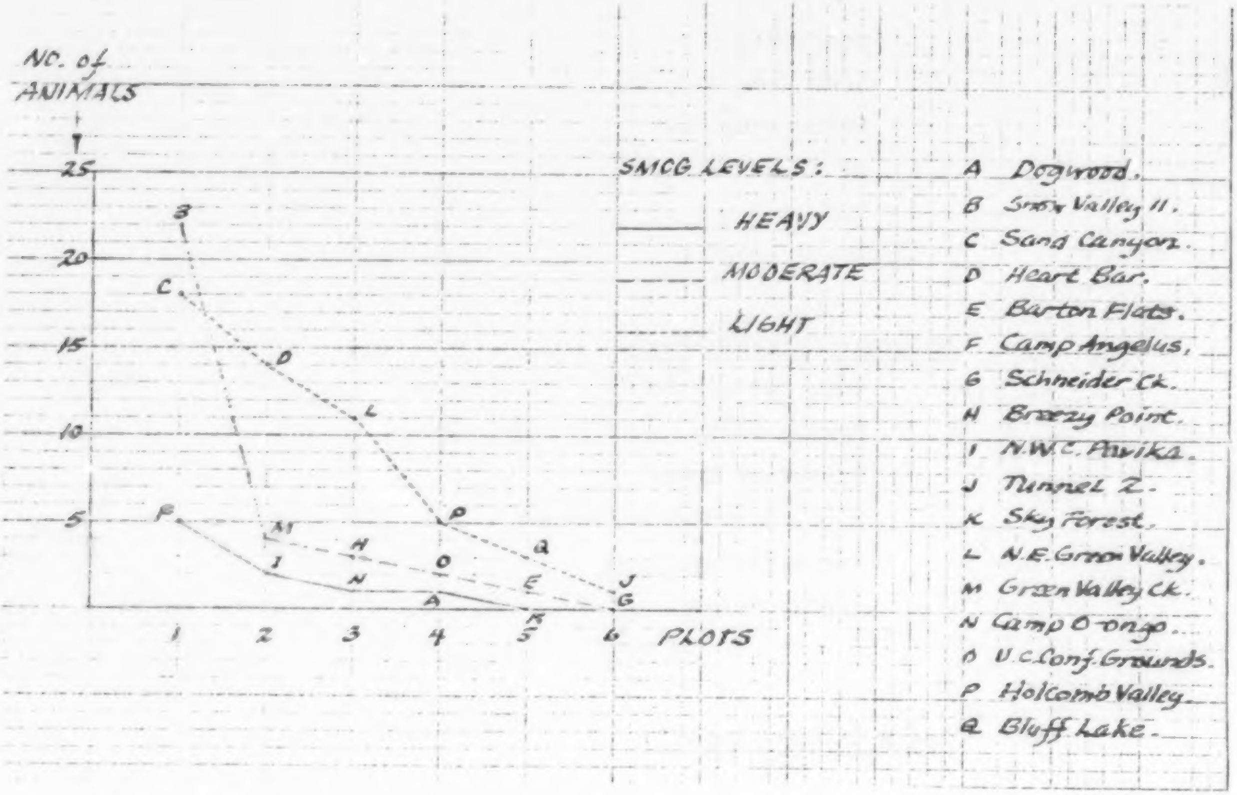


Fig. 4. Comparison of 1973 small mammal trapping results and oxidant levels on 17 plots.

the winter, affording no protection for small mammals until well into the spring months. While vegetation analysis of the 11 new plots is not yet complete, many of the light and moderate oxidant pollution level plots have subcanopy vegetation that is either of the annual type or of plants that depend on rhyzome nodes for perennation. On 8 May 1974, for example, the subcanopy vegetation on Breezy Point was non-existant except for a scattering of spring flowers.

Low tree densities correspond to higher numbers of animals caught. Sand Canyon and Heart Bar have low tree densities (46.5 trees/acre and 59.6 trees/acre respectively) while Dogwood, Barton Flats, and Camp Angelus have high tree densities (107.30, 146.30, and 220.16 trees/acre respectively). High tree density corresponds to percent crown closure. Many small mammal food and shelter sources may be shaded out by the high tree density/canopy closure combination.

Since the oxidant gradient parallels a moisture gradient in the San Bernardino mountains, the low pollution plots were also the most xeric. Precipitation figures for the 11 new plots are not yet available, but amounts of precipitation and subcanopy vegetation are related.

The 1972 and 1973 trapping seasons have netted 176 small mammals for laboratory analysis. Analyses of population health, productivity and structure continue. The food habits are being directed at assessing the importance of cone and seed crops as an animal food supply and the role of fruiting bodies of pathogenic and non-pathogenic fungi in the food supply.

Yellow Pine Seed Utilization

A. Introduction:

The western gray squirrel is the only diurnal, arboreal, pine-seed-eater in the small mammal population of the San Bernardino mountains. It is the only small mammal in this region known to cut pine cones from the trees. The northern flying squirrel (*Glaucomys sabrinus*) is the only other potential member of this society. It has been excluded from consideration partly because its nocturnal secretive habits make direct observation difficult and because it is not primarily a seed-eater (Ingles 1965). However, the flying squirrel occurs in moderate numbers in the San Bernardino mountains and could be a factor in yellow pine cone utilization. The gray squirrel, occuring in moderate populations throughout the yellow pine/black oak (*Quercus kelloggii*) habitat unit, may be exerting considerable pressure on the development of yellow pine cones. Study of cone utilization will help answer this question, as well as describe the relationship between cone-crop abundance and gray squirrel population densities. Yellow pine forests in the San Bernardinos must periodically produce cones despite the synergistic forces of oxidant damage and highly variable precipitation and soil quality. Squirrels have been shown to be highly destructive on cone crops during years of low cone production (Fowells and Schubert 1956, Larson and Schubert 1970). Should the forces antagonistic to cone crop production lower the actual cone production, the gray squirrel could be a major factor in further reducing yellow pine regeneration.

B. Procedure:

Eight of the general study plots were selected for a cone utilization survey. Two plots (Tunnel 2 and Northeast Green Valley) represented areas of low oxidant air pollution, three (Breezy Point, Schneider Creek, and Green Valley Creek) had moderate levels of pollution, and three (Sky Forest, Camp O-Ongo, and Camp Angelus) had high levels. The ground area beneath the canopy of yellow pine trees or tree groups (where proximity of growth caused crowns to close) was swept of cut cones. Each cone collection was placed in a plastic bag and marked with plot name, tree identification number(s), date of collection, and notes of current feeding activity. Mature cones were later separated from developing conelets (next year's cone crop) and counted. Seeds were extracted from closed cones by peeling off bracts and pinching out the seed with forceps. All seed collected at an individual plot at a particular time was so noted and placed in a bag. Bags were loosely tied to prevent spillage and allow for air exchange. Seed bags were stored in a refrigerator for subsequent viability and germination trials.

C. Results:

We were able to observe gray squirrel cone utilization on a number of occasions. A typical observation occurred on the afternoon of 28 August at the Camp Angelus study plot. Two gray squirrels were spotted working the upper canopy of 100-foot mature ponderosa pines about 50 meters apart. In 36 minutes one of the squirrels (a lactating female) picked out, cut, carried back to her "feeding station," and utilized 5 mature cones, or about a cone every 7 minutes. Table 4 taken from field notes for 28 August summarizes the times and nature of the feeding activity. This large individual cut cones from the outer branches and returned with the cone held

Table 4. Observations of an individual gray squirrel feeding on ponderosa pine cones at Camp Angelus study plot, 28 August 1973. (Time period of observation 1451-1528).

Cone No.	Activity	Time of activity	Elapsed time from beginning of observation
1	picking and eating[a]	:05.15	05.15
2	picking	:00.30	:05.45
2	eating	:08.35	:14.20
3	picking[a]	:00.15	:14.35
3	eating	:05.25	:20.00
3	grooming	:00.30	:20.30
4	picking	:00.20	:20.50
4	carrying	:00.10	:21.00
4	eating	:06.20	:27.20
5	searching / picking	:00.55	:28.15
5	carrying	:00.10	:28.28
5	eating	:08.05	:36.33

[a] carrying time not recorded

in the mouth to the base of a large branch about 70 feet above the forest floor. Sitting hunched over the cone with hindquarters toward the tree trunk and the tail dangling off the branch, the squirrel held the ends of the cone down against the branch with either forepaw. Twirling the cone on its axis, the squirrel threw back her head about every 3 seconds and released a bract. (The actual chewing process could not be viewed in sufficient detail). 2 of the 5 cones utilized in this episode did not fall to the floor. Cones collected on the ground, then, represent only a portion of the total number utilized.

A summary of cone utilization on the 8 plots is presented in Table 5. Collection and observations encompassed the period between 17 August and 20 September. Cone-cutting and cone utilization continued on a few trees on 5 of the 8 plots throughout the period. This period, however, apparently followed the height of cone-cutting activity in the SBNF in 1973. Squirrels started cutting cones as early as the last week in June (Jerome Light pers. comm.) and the great majority of utilized cones were found in the first week of collection (20 to 28 August).

Squirrels concentrated their cone utilization on a few individual trees (preferred trees) on each of the 8 plots (Table 5.). A single tree or small tree-group on each plot accounted for an average of 59.2 percent of the cones utilized. Only 21 percent of the trees whose cones were utilized at some time during the five-week period were utilized during each collection and observation interval.

Table 5. Yellow pine seed utlization on 8 study plots.

Time period	Plot	No. utilized cones	No. utilized conelets	Percent use on preferred trees	No. tree utilized every ye
17 Aug. - 20 Sept.	Tunnel 2	969	1	61.0	3
20 Aug. - 20 Sept.	Sky Forest	1722	38	44.7	4
20 Aug.- 20 Sept.	Breezy Point	1019	35	77.4	1
23 Aug. - 20 Sept.	Camp O-ongo	64	0	60.9	0
30 Aug. - 20 Sept.	Schneider Creek	887	0	84.9	0
24 Aug. - 20 Sept.	NE Green Valley	30	3	33.3	0
28 Aug. - 20 Sept.	Camp Angelus	2394	12	24.1	7
24 Aug. - 20 Sept.	Green Valley Cr.	167	6	87.4	1
	Total:	7252	95	-	16
	$\bar{X}$ per plot :	906.5	10.9	59.2	2

D. Discussion:

The cone utilization survey yielded information on various aspects of squirrel utilization of yellow pine cones. The gray squirrel played a significant role in the destruction of yellow pine regenerative power in 1973. Large numbers of utilized cones were collected (Table 5). Often these cones represented a major portion or the entire cone production of individual trees and collectively for entire plots(Table 6).

We did not find many instances of conelets (next year's cones) being cut. Only 95 conelets that had been fed upon were collected, compared to 7252 mature cones. The ratio of .013 conelets:cones is small compared with results reported by Roeser (1941), Squillace (1953), Hooven (1968), and Shearer and Schmidt (1971). It appears that in 1973 the squirrels did not cut terminal, conelet-bearing branches incidental to cutting the mature cones as they do in other forests.

Squirrels utilize cones from arboreal perches. Bracts filtering down through the crown from arboreal feeding sites are distributed randomly beneath the tree canopy. When feeding on the ground, squirrels do not scatter the bracts randomly, but instead one finds a close group of bracts surrounding the cone axil. With one exception, the only ground-feeding on cones noted in the SBNF by squirrels was upon sugar pine (Pinus lambertiana). In such instances, the squirrels probably find the enormous sugar pine cones too difficult to maneuver in the trees. Cutting a cone, they follow it down to the ground to utilize it.

Table 6. Number of cones produced and utilized on 6 study plots.

Plot	Tree ID no.	No. cones utilized	Cone production	Time utilized cones collected	Time cone-count
CA	7		90	28 Aug. - 20 Sept.	31 July - 3 Aug.
	14		233		
	15		606		
		577	929		
	72		6		
	77		283		
		161	289		
	79	454	162		
	53	103	130		
T2	419	263	543	25 July - 20 Sept.	31 Oct.
	463	591	115	20 Aug. - 20 Sept.	
SKY For	1439		0		
	1440		4		5 Nov.
	1445		0		
	1454		5		
		318	9		
	1377		0		
	1380		13		
		135	13		
	1344		21		
	1357		14		
		135	35		
	1431		13		
	1432		0		
		106	13		
B POINT	314	71	0		
	363	68	0		
O-ONGO	895		2	23 Aug. - 20 Sept.	
	897		0		
		39	2		
	868	9	4		
NEGV	635		0	24 Aug. - 20 Sept.	
	636		11		
	639		4		
	643		7		
		10	22		
	648		0		
	649		1		
	650		0		
		9	1		
	645	7	15		

We intend to run viability and germination studies on our collected seed. This is seed disseminated by the gray squirrel during the utilization process. We expect to find that the majority of the seed is not viable or is immature seed and thus will not germinate since most of the seed was collected prior to maturity. This information is important in determining the impact of the gray squirrel on pine regeneration. Dissemination of viable/germinable seed makes the gray squirrel partly a positive factor in pine regeneration. Clearly the cutting of cones and dissemination of seeds prior to seed maturity destroys pine regeneration potential. Berry (1914) stated that during the particularly poor seed crop year of 1910, squirrels began cutting ponderosa cones as early as the last two weeks of July - two months prior to maturity. Squillace (1953) indicatd that the first cutting in the Rockies occurred in July with 15 percent of the cones cut by August. The gray squirrel began cutting the cones the last week in June in the SBNF in 1973. On one survey conducted in the vicinity of Breezy Point, we found all cone-bearing ponderosa pines stripped of cones by 17 July. Gray squirrels began cutting cones three months prior to cone maturity, and in some areas cut 100 percent of the cones two months prior to cone maturity. In such areas squirrels have totally destroyed the current seed crop.

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